



computer-supported collaborative learning

July 4-8, 2011 ✿ Hong Kong, China

Connecting research
to
policy and practice

Conference Proceedings Volume II

Short papers & posters

Editors: Hans Spada, Gerry Stahl, Naomi Miyake, Nancy Law



International Society of
the Learning Sciences



Centre for
Information Technology
in Education
The University of Hong Kong

Connecting computer-supported collaborative learning to policy and practice

CSCL2011 CONFERENCE PROCEEDINGS
VOLUME II
SHORT PAPERS & POSTERS

9th International Computer-Supported Collaborative Learning Conference
July 4-8, 2011, Hong Kong, China

Title:

Connecting Computer-Supported Collaborative Learning to Policy and Practice:
CSCL2011 Conference Proceedings Volume II — Short Papers & Posters

Editors:

Hans Spada, Gerry Stahl, Naomi Miyake, Nancy Law

Citation format:

Spada, H., Stahl, G., Miyake, N., Law, N. (Eds.) (2011) *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings. Volume II — Short Papers & Posters*. International Society of the Learning Sciences.

ISBN:

© 2011, INTERNATIONAL SOCIETY OF THE LEARNING SCIENCES [ISLS]
Copyright 2011 International Society of the Learning Sciences, Inc. Rights reserved



All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, without the prior written permission of the International Society of the Learning Sciences.

The International Society of the Learning Sciences is not responsible for the use which might be made of the information contained in this book.

<http://www.isls.org/>

Published by:

International Society of the Learning Sciences (ISLS)

Proceedings Printed by:

LuLu

<http://www.lulu.com>

Proceedings Distributed by:

LuLu and Amazon

Book Cover Design:

Debbie Pang, Multimedia Web Designer

Centre for Information Technology in Education (CITE), The University of Hong Kong

<http://www.cite.hku.hk/>

Conference Organizers and Supporting Organization

Organizers

- The International Society of the Learning Sciences
- Centre for Information Technology in Education, The University of Hong Kong

Co-organizers

- Beijing Normal University
- East China Normal University
- South China Normal University

Supporting Organization

- Education Bureau, the Hong Kong Special Administrative Region

Conference Sponsors

Platinum Sponsor

- Strategic Research Theme (SRT) on the Sciences of Learning, The University of Hong Kong

Gold Sponsors

- Hong Kong Applied Science and Technology Research Institute
- Sunny Interactive

Other Sponsor

- Bank of East Asia

Steering Committee

Conference Chairs

- Nancy Law, The University of Hong Kong, China
- Kai Ming Cheng, The University of Hong Kong, China

Program Chairs

- Hans Spada, Freiburg University, Germany
- Gerry Stahl, Drexel University, USA
- Naomi Miyake, University of Tokyo, Japan

Pre-conference Workshops and Tutorials Chairs

- Daniel Suthers, University of Hawai'i, USA
- Iris Tabak, Ben Gurion University of the Negev, Israel
- Chee Kit Looi, Nanyang Technological University, Singapore

Post-conference Events and Tutorials Chairs

- Ronghuai Huang, Beijing Normal University, China
- Shengquan Yu, Beijing Normal University, China
- Zhiting Zhu, East China Normal University, China
- Youqun Ren, East China Normal University, China
- Fuyin Xu, South China Normal University, China
- Hongguang Peng, Guangdong Center of Educational Technology, China
- Baohui Zhang, National Institute of Education, Singapore
- Siu Cheung Kong, The Hong Kong Institute of Education
- Nancy Law, The University of Hong Kong

Doctoral Consortium Chairs

- Kristine Lund, University of Lyon, France
- Christopher Hoadley, New York University, USA
- Carol Chan, The University of Hong Kong

Early Career Workshop Chairs

- Frank Fischer, University of Munich, Germany
- Cindy Hmelo-Silver, Rutgers University, USA
- Tak Wai Chan, National Central University, Chinese Taipei

Interactive Events, Demonstrations and CSCL in Practice Showcases Chairs

- Therese Laferriere, University of Laval, Canada
- Katerine Bielaczyc, Nanyang Technological University, Singapore
- Sadhana Puntambekar, University of Wisconsin-Madison, USA
- Nancy Songer, University of Michigan, USA
- Sanna Javela, University of Oulu, Finland

Community Memory Chair

- Ricki Goldman, New York University, USA
- Diane Stormont, University of Hong Kong
- Kevin Lau, University of Hong Kong

International Relations Chairs

- Peter Reimann, University of Sydney, Australia
- Tak Wai Chan, National Central University, Chinese Taipei
- Paivi Hakkinen, University of Jyväskylä, Finland

Advisors

- Ying Chan, The University of Hong Kong
- Paul Kirschner, Open University, Netherlands
- Claire O'Malley, University of Nottingham, UK
- Janet Kolodner, Georgia Institute of Technology, USA
- Daniel Suthers, University of Hawai'i, USA

Local Organizing Committee (The University of Hong Kong)

Local Organization Chair

- Prof. Nancy Law

Paper Submission and Review

Process Technological System Chair

- Mr. Murphy Wong
- Mr. Simon Leung

Graphic Designer and Website Chair

- Ms. Debbie Pang

Proceedings Editing Chairs

- Dr. Man Wai Lee
- Dr. Tamara Savelyeva

Technology Support and Registration System Chair

- Mr. Murphy Wong
- Mr. Geoffrey R. Dengate

Mainland China Post-conference Coordinators

- Dr. Jingyan Lu
- Dr. Ming Lai

Policy Forum Coordinator

- Dr. Jae Park

Interactive Events Coordinators

- Dr. Yeung Lee
- Mr. Johnny Yuen

Pre-conference Events Coordinator

- Mr. Ron Tsoi

Posters Coordinator

- Mr. Ron Tsoi

Community Memory Chairs

- Dr. Bob Fox
- Dr. Felix Siu
- Mr. Simon Leung

Program Booklet Editing Chair

- Dr. Allan Yuen

Registration and Attendee Materials Chair

- Ms. Bella Chow

Running Conference Coordinator

- Ms. Candy Leung

Social Events Chairs

- Ms. Candy Leung
- Dr. Jae Park

Students Volunteer Chairs

- Dr. Alvin Kwan
- Mr. Peter Warning

Treasurer

- Ms. Candy Leung

Mainland China Post-conference

Local Organizing Committee (Guangzhou)

Chairs

- Fuyin Xu
South China Normal University
- Jun Xu
South China Normal University
- Hongguang Peng
Guangdong Center of Educational Technology

Members

- Xionghui Chen
South China Normal University
- Jianli Jiao
South China Normal University
- Junfen Lin
Guangdong Center of Educational Technology
- Jianhua Zhao
South China Normal University
- Qianwei Zhang
South China Normal University
- Su Mu
South China Normal University

Local Organizing Committee (Shanghai)

Chairs

- Zhiting Zhu
East China Normal University
- Youqun Ren
East China Normal University
- Pengkai Pan
Saybot Information Technology (Shanghai) Co., Ltd.

Members

- Xinning Pei
East China Normal University
- Xianze Cai
Saybot Information Technology (Shanghai) Co., Ltd.
- Hanbing Yan
East China Normal University
- Jian Zhao
East China Normal University
- Xiaoqing Gu
East China Normal University
- Bin He
East China Normal University

Local Organizing Committee (Beijing)

Chairs

- Ronghuai Huang
Beijing Normal University
- Shengquan Yu
Beijing Normal University

Members

- Mang Li
Beijing Normal University
- Yanyan Li
Beijing Normal University
- Liang Yu
Beijing Normal University
- Yanqin Zheng
Beijing Normal University

REVIEWERS OF CSCL2011 CONFERENCE

The conference chairs and program chairs sincerely thank the following 293 scientists who reviewed proposals for the CSCL2011 conference.

Abrahamson, Dor, University of California, Berkeley
 Abramovich, Sam, University of Pittsburgh
 Acholonu, Ugochi, Stanford University
 Albury, Steven, University of Oxford
 Aleahmad, Turadg, Carnegie Mellon University
 Alterman, Richard, Brandeis University
 Anjewierden, Anjo, University of Twente
 Arena, Dylan, Stanford University
 Arnseth, Hans Christian, Department of Education, University of Oslo
 Asensio, Juan I., University of Valladolid
 Avouris, Nikolaos, University of Patras
 Bader-Natal, Ari, Grockit, Inc.
 Bagley, Elizabeth, University of Wisconsin-Madison
 Bairral, Marcelo, Federal Rural University of Rio de Janeiro (UFRRJ)
 Baker, Michael, CNRS - Telecom ParisTech
 Bauters, Merja, Helsinki Metropolia University of Applied Sciences
 Bennerstedt, Ulrika, University of Gothenburg
 Bermundo, Cesar, Ateneo de naga University
 Blavier, Adelaide, University of Liège
 Bodemer, Daniel, University of Tubingen
 Bouyias, Yannis, Aristotle University of Thessaloniki
 Bratitsis, Tharrenos, University of Western Macedonia, Greece
 Brennan, Karen, MIT Media Lab
 Bruckman, Amy, Georgia Tech
 Buder, Juergen, KMRC Tuebingen
 Bures, Eva, Bishop's University
 Cakir, Murat, Drexel University
 Carell, Angela, University of Bochum
 Cavallo, Alice, Harvard
 Chan, Carol, University of Hong Kong
 Chan, Margaret, Columbia University
 Chan, Tak-Wai, National Central University
 Chang, Ben, National Chiayi University
 Chapman, Robbin, Massachusetts Institute of Technology
 Charles, Elizabeth, Dawson College
 Chau, Clement, Tufts University
 Chen, Ching-Huei, National Changhua University of Education
 Chen, Fei-Ching, National Central University, NCU
 Chen, Wenli, National Institute of Education
 Cherniavsky, John, National Science Foundation
 Ching, Yu-Hui, Boise State University
 Churchill, Daniel, University of Hong Kong
 Clarke-Midura, Jody, Harvard Graduate School of Education
 Clegg, Tamara, Georgia Institute of Technology
 Code, Jillianne, Harvard University
 Condamines, Thierry, Laboratoire MIS
 Cress, Ulrike, Knowledge Media Research Center
 Daily, Shaundra, g8four
 Damsa, Crina, University of Oslo
 Dascalu, Mihai, University Politehnica of Bucharest
 Dasgupta, Chandan, University of Illinois at Chicago
 de Jong, Frank, Stoas University of Applied Sciences and teacherr Education
 de Leng, Bas, Maastricht University
 Deiglmayr, Anne, University of Freiburg
 Demetriadis, Stavros, Aristotle University of Thessaloniki, Greece
 Demmans Epp, Carrie, University of Saskatchewan
 DeVane, Ben, University of Florida
 Di Blas, Nicoletta, Politecnico di Milano
 Dillenbourg, Pierre, EPFL
 Dimitriadis, Yannis, University of Valladolid
 Dirckinck-Holmfeld, Lone, Aalborg University
 DiSalvo, Betsy, Georgia Institute of Technology
 Diziol, Dejana, University of Freiburg
 Dowell, John, University College London
 Dugstad Wake, Jo, University of Bergen, UiB
 Duncan, Sean, Miami University
 Dyke, Gregory, Ecole Nationale Supérieure des Mines de Saint-Etienne
 Engelmann, Tanja, Knowledge Media Research Center
 Erlandson, Benjamin, California State University, Monterey Bay
 Ertl, Bernhard, Universität der Bundeswehr München
 Evans, Michael, Virginia Tech
 Feldmann, Birgit, University of Hagen
 Fesakis, Georgios, University of Aegean
 Fields, Deborah, University of California, Los Angeles
 Filsecker, Michael, Duisburg-Essen University
 Fischer, Frank, University of Munich
 Fischer, Gerhard, University of Colorado, Boulder
 Forte, Andrea, Drexel University
 Fox, Bob, University of Hong Kong
 Fujita, Nobuko, OISE/UT
 Fuks, Hugo, Catholic University of Rio de Janeiro
 Gegenfurtner, Andreas, University of Turku

- George, Sebastien, INSA de Lyon
 Goggins, Sean, Drexel University College of
 Information Science & Technology
 Gogoulou, Agoritsa, Department of Informatics &
 Telecommunications, University of Athens
 Gouli, Evangelia, University of the Aegean
 Grant, Jamillah, Northcentral University
 Gressick, Julia, University of Wisconsin- Madison
 Guribye, Frode, University of Bergen
 Häkkinnen, Päivi, University of Jyväskylä, Finnish
 Institute for Educational Research
 Haake, Joerg, FernUniversitaet in Hagen
 Hackbarth, Alan, University of Wisconsin-Madison
 Halverson, Erica, University Of Wisconsin -
 Madison
 Hayama, Tessai, Japan Advanced Institute of
 Sience and Technology
 Heo, Gyeong Mi, CEFRIO
 Hernandez, Juan Carlos, Open University Colombia
 UNAD
 Herodotou, Christothea, Cyprus University of
 Technology
 Herrmann, Thomas, University of Bochum,
 Germany
 Hilbert, Tatjana, University of Mainz
 Hmelo-Silver, Cindy, Rutgers University
 Hoidn, Sabine, Harvard University, School of
 Education
 Hong, Huang-Yao, National Chengchi University
 Hong, Kian Sam, Universiti Malaysia Sarawak
 Honwad, Sameer, Rutgers University
 Hoppe, H. Ulrich, University of Duisburg-Essen
 Horn, Michael, Northwestern University Learning
 Sciences
 Horney, Mark, University of Oregon
 Hsu, Yu-Chang, Boise State University
 Hubscher, Roland, Bentley University
 Hui, Diane, The University of Hong Kong
 Ioannou, Andri, Cyprus University Of Technology
 Iordanou, Kalypso, Neapolis University
 Jacobson, Michael, The Univerisity of Sydney
 Jahnke, Isa, Dortmund University of Technology
 Janssen, Jeroen, Utrecht University
 Jeong, Heisawn, Hallym University
 Joiner, Richard, University of Bath
 Juang, Yih-Ruey, Jinwen University of Science and
 Technology
 Kafai, Yasmin, ucla education
 Kali, Yael, University of Haifa
 Kang, Haijun, Jackson State University
 Kaptelinin, Victor, University of Bergen, Norway
 Kapur, Manu, National Institute of Education
 Karakostas, Anastasios, Aristotle University of
 Thessaloniki
 Khan, Azam, Autodesk, Inc.
 Khine, Myint Swe, Emirates College for Advanced
 Education
 Kim, Beaumie, National Institute of Education
 Kim, Kibum, Virginia Tech
 Kim, Mi Song, Nanyang Technological University
 Kimmerle, Joachim, University of Tuebingen,
 Department of Applied Cognitive Psychology
 and Media Psychology
 Kirschner, Paul, Open University of the
 Netherlands
 Knipfer, Kristin, University of Tuebingen
 Koh, Myung, Riverside City College
 Koops, Willem, Máxima Medical Center
 Kopp, Birgitta, University of Munich
 Koumpis, Adamantios, ALTEC
 Kraemer, Nicole, University Duisburg-Essen
 Krange, Ingeborg, InterMedia, University of Oslo
 Krumm, Andrew, University of Michigan
 Kumar, Swapna, University of Florida
 Kwon, Samuel, Concordia University Chicago
 Kyza, Eleni, Cyprus University of Technology
 Lütticke, Rainer, Bochum University of Applied
 Sciences
 Laferriere, Therese, Laval University
 Laffifi, Yacine, LAIG Laboratory, Guelma University,
 Algeria
 Lai, Ming, The University of Hong Kong
 Lakkala, Minna, University of Helsinki
 Lambropoulos, Niki, Intelligenesis
 Lan, Yu-Ju, National Taiwan Normal University
 Lansiquot, Reneta, New York City College of
 Technology
 Larusson, Johann, Brandeis University
 Lazakidou, Georgia, University of Piraeus
 Levy, Dalit, HIT
 Li, Ken W., Hong Kong Institute of Vocational
 Education (Tsing Yi)
 Li, wenjuan, University of Illinois at Chicago
 Li, Xiao, Southwest China University
 Liao, Chang-Yen, Graduate Institute of Network
 Learning Technology, National Central
 University
 Lim, Jung, Northwestern State University
 Lindgren, Robb, University of Central Florida
 Lindwall, Oskar, Göteborg University
 Lingnau, Andreas, University of Strathclyde
 Lipponen, Lasse, University of Helsinki
 Liu, Lei, University of Pennsylvania
 Lonchamp, Jacques, LORIA - University of Nancy
 Lonn, Steven, University of Michigan
 Looi, Chee-Kit, Nanyang Technological University
 Lorek, Edward, Naval Air Systems Command 4.6
 Lu, Jingyan, The University of Hong Kong
 Luckin, Rosemary, The London Knowledge Lab
 Ludvigsen, Sten, InterMedia
 Lund, Andreas, University of Oslo
 Lund, Kristine, ICAR
 Lyons, Leilah, University of Illinois at Chicago
 Mäkitalo-Siegl, Kati, University of Jyväskylä

- Mahardale, Jay, Admiralty Primary School, Ministry of Education
- Makara, Kara, University of Michigan
- Manca, Stefania, Institute for Educational Technology, Italian National Research Council
- Markauskaite, Lina, The University of Sydney
- Martínez-Monés, Alejandra, University of Valladolid
- Mavrikis, Manolis, Institute of Education
- McLaren, Bruce, Carnegie Mellon University
- Medina, Richard, Laboratory for Interactive Learning Technologies
- Mercier, Emma, Durham University
- Mochizuki, Toshio, Senshu University
- Molinari, Gaelle, Distance Learning University Switzerland
- Mor, Yishay, London Knowledge Lab
- Moraveji, Neema, Stanford University
- Morch, Anders, InterMedia. University of Oslo
- Muehlpfordt, Martin, FernUniversitaet Hagen
- Mwanza-Simwami, Daisy, The Open University
- Najafi, Hedieh, Ontario Institute for Studies in Education
- Noroozi, Omid, Wageningen University
- Notari, Michele, School of Teacher Education PHBern
- Nwaigwe, Adaeze, American University of Nigeria
- Oehl, Michael, Leuphana University of Lueneburg
- Ogata, Hiroaki, University of Tokushima
- Oshima, Jun, Shizuoka University
- Oshima, Ritsuko, Shizuoka University
- Palmquist, Sasha, Institute for Learning Innovation
- Pan, Rui, Purdue University
- Papanikolaou, Kyparisia, School of Pedagogical and Technological Education, ASPETE
- Pea, Roy, Stanford University
- Pemberton, Lyn, University of Brighton
- Penuel, William, SRI International
- Pfister, Hans-Rüdiger, University of Lüneburg
- pierroux, palmyre, university of oslo
- Pifarré, Manoli, Universitat de Lleida
- Pinkwart, Niels, Clausthal University of Technology
- Price, Sara, Institute of Education
- Rebedea, Traian, Politehnica University of Bucharest
- Reedy, Gabriel, King's College London
- Reever, Richard, Queen's University
- Reimann, Peter, University of Sydney
- Renninger, K. Ann, Swarthmore College
- Richter, Christoph, Christian-Albrechts-Universität zu Kiel
- Rick, Jochen, Saarland University
- Roberts, Tim, Central Queensland University
- Rogers, Jim, Utah State University
- Roll, Ido, University of British Columbia
- Romero, Margarida, Université of Toulouse, CLLE-LTC (UMR 5263)
- Roschelle, Jeremy, SRI International
- Rose, Carolyn, Carnegie Mellon University
- Rummel, Nikol, Ruhr-Universität Bochum
- Rusman, Ellen, Open University of the Netherlands
- Salden, Ron, Madeira Interactive Technologies Institute
- Saleh, Asmalina, Indiana University Bloomington
- Schmidt, Matthew, University of Missouri
- Schroeder, Ulrik, RWTH Aachen University
- Schwendimann, Beat, UC Berkeley
- Sethi, Ricky, UCLA
- Shaoming, Chai, South china Normal University
- Shirouzu, Hajime, Chukyo University
- Sie, Rory, Open Universiteit in the Netherlands
- Simon, Jean, Institut Universitaire de Formation des Maitres
- Siyahhan, Sinem, Indiana University
- Slof, Bert, University of Groningen
- Smith, Garrett, University of Wisconsin - Madison
- So, Hyo-Jeong, National Institute of Education, Nanyang Technological University
- Stegmann, Karsten, University of Munich
- Steinkuehler, C, University of Wisconsin-Madison
- Stoyanov, Slavi, Open University of the Netherlands (OUNL)
- Strijbos, Jan-Willem, Leiden University
- Subramaniam, Nantha Kumar, Open University Malaysia
- Suthers, Dan, University of Hawaii
- Svihla, Vanessa, The University of Texas at Austin
- Sylvan, Elisabeth, MIT Media Lab
- Tabak, Iris, Ben Gurion University
- Tartaro, Andrea, Union College
- Tchounikine, Pierre, LIG
- Teasley, Stephanie, University of Michigan
- Teplovs, Christopher, OISE/UT
- Thomas, Jakita, Spelman College
- Trausan-Matu, Stefan, Politehnica University of Bucharest
- Trninic, Dragan, University of California, Berkeley
- Tsiatsos, Thrasylvoulos, Aristotle University of Thessaloniki
- Tzagarakis, Manolis, Research Academic Computer Technology Institute
- Underwood, Jody, Pragmatic Solutions, Inc.
- Underwood, Joshua, London Knowledge Lab
- van Aalst, Jan, The University of Hong Kong
- Van Amelsvoort, Marije, Tilburg University
- van de Sande, Carla, Arizona State University
- van Leeuwen, Anouschka, Utrecht University
- van 't Hooft, Mark, Kent State University
- Vanover, Charles, University of South Florida Saint Petersburg
- Vatrapu, Ravi, Copenhagen Business School
- Verdines, Patricia, Tecnologico de Monterrey
- Vignollet, Laurence, Université de Savoie

Vu Minh, Chieu, University of Michigan, School of Education
Walker, Erin, Carnegie Mellon University (CMU)
Wang, Xinghua, University of Munich
Wardrip, Peter, University of Pittsburgh
Warner, Norman, Naval Air Systems Command
Wecker, Christof, University of Munich, Department of Psychology
Wee, Juan Dee, National Institute of Education, Nanyang Technological University
Wessner, Martin, Fraunhofer IESE
White, Tobin, UC Davis
Wilkerson-Jerde, Michelle, Northwestern University
Winter, Marcus, University of Brighton
Wise, Alyssa, Simon Fraser University

Wong, Lung Hsiang, National Institute of Education
Woo, David, University of Hong Kong
Wopereis, Iwan, Centre for Learning Sciences and Technologies - Open University of the Netherlands
Xhafa, Fatos, Technical University of Catalonia
Yacef, Kalina, School of Information Technologies
Yeo, Jennifer, National Institute of Education
Yoo, Jaebong, USC/ISI
Yoon, Susan, University of Pennsylvania
Yu, Fu-Yun, National Cheng Kung University
Yuen, Johnny K.L., University of Hong Kong
Zahn, Carmen, Knowledge Media Research Centre
Zhang, Jianwei, University at Albany, SUNY
Zhou, Nan, Drexel University
Zourou, Katerina, University of Luxembourg

Introduction to the Proceedings of CSCL 2011

Gerry Stahl, Hans Spada, Naomi Miyake, Nancy Law

The Scientific Field of CSCL

Computer-Supported Collaborative Learning (CSCL) is a multidisciplinary research field inspired by the power of collaborative learning and by the promise of computer technologies to support collaborative learning. It draws on and explores constructivist and socio-cultural theories, which view learning as a social, interpersonal, meaning-making process that takes place largely through interaction among people and within communities. It also designs, adopts and refines technologies that mediate communication among learners and that help to guide their inquiry or structure their work.

As a research field, CSCL builds on conceptual frameworks and analytic approaches of many academic fields, including education, psychology, communication, computer science and social science. It applies a variety of quantitative and qualitative research methods, often combining them to develop richer understandings of complex phenomena. Likewise, it may involve both laboratory and classroom studies, formal and informal learning settings, different temporal scales and the study of a wide range of influential factors.

Policies and Practices for CSCL

While the CSCL conference series has centered on research studies, the field has always been strongly oriented toward practical concerns of educational practice and associated educational policy. CSCL research frequently involves teachers in school classrooms and seeks to influence or implement governmental education policies.

The CSCL 2011 conference theme, “*Connecting computer-supported collaborative learning to policy and practice*,” builds on previous CSCL conferences to examine whether and how CSCL practices can bring deep changes to formal and informal educational practices at all levels, and contribute to educational improvement at a system level by informing education policy. This theme is addressed by keynote talks, symposia, trips to schools, and other events at the conference and the post-conference. It is hoped that this conference theme will contribute to bringing greater recognition to the fields of CSCL and the Learning Sciences by drawing the attention of a wider public, including policy makers and the professional educational community to their research and development contributions.

One important feature of this year’s conference is the inclusion of three parallel tracks of interactive events, demonstrations and CSCL-in-practice showcases, which serve as the foci for attracting practitioners to the conference. Included in these practitioner-oriented events are presentations from several prominent school-university partnership projects that are themselves good exemplars of the conference theme in action. The conference has the support of policy makers in Hong Kong to sponsor teacher participation at the conference; the Education Bureau of the HKSAR Bureau is a supporting organization for this conference. The practitioner tracks are also made possible through the merger of other conferences into this year’s CSCL conference. This year, the annual Knowledge Building Summer Institute, which has usually been held in Toronto, Canada, has been integrated into the CSCL conference in Hong Kong and Guangzhou.

To take advantage of CSCL 2011 being held in Hong Kong, CITE collaborated with East China Normal University, South China University and Beijing Normal University to co-organize a series of CSCL 2011 post-conference events in Shanghai, Guangzhou and Beijing respectively on July 11-15. It is the first time that there are such major post-conference events for the CSCL conference and we hope this will provide more opportunities for academic exchange and collaboration between CSCL and learning sciences researchers in Greater China and their global counterparts.

The CSCL Community and Conference

Since 1995, the CSCL conference has provided a stimulating and friendly venue for people interested in the multi-disciplinary issues of computer-supported collaborative learning to meet in a relaxed atmosphere with a variety of formal and informal events. Structured activities and social occasions promote interpersonal relations and knowledge building. The conference’s human size and structure facilitate getting to know international colleagues and discussing cutting-edge ideas in educational practice, technology design, CSCL theory and diverse research approaches.

The bi-annual conferences have been instrumental in developing the field of CSCL and in building the research community around it. The conferences took place in Bloomington, USA (1995), Toronto, Canada

(1997), Stanford, USA (1999), Maastricht, Netherlands (2001), Boulder, USA (2002), Bergen, Norway (2003), Taipei, Taiwan (2005), New Brunswick, USA (2007) and Rhodes, Greece (2009).

Further efforts to build the CSCL field include the founding of the International Society of the Learning Sciences (ISLS) by the CSCL community and the Learning Sciences research community. ISLS now provides an institutional framework for running the CSCL and ICLS conferences in alternating years and for publishing the *International Journal of Computer-Supported Collaborative Learning (ijCSCL)* and the *Journal of the Learning Sciences (JLS)*. In the early days of CSCL research, there was no publication venue specifically oriented to the field and it was hard to locate publications in the field. Now, in addition to the CSCL journal, there is also a CSCL book series sponsored by ISLS and published by Springer. Furthermore, papers from the CSCL and ICLS conferences are available in the ACM Digital Library and both *ijCSCL* and *JLS* are abstracted in the major indexing services, where they are highly ranked.

Toward a Global CSCL

The first CSCL conference was a relatively simple event, held in the middle of the United States. Over the years, the conference expanded to include a variety of sessions to meet the needs of a growing research community. It now features long papers presented lecture style, posters presented interactively and short papers presented in a hybrid style, to accommodate research findings ranging from early work to more mature reports. There are also tutorials for newcomers and workshops for special hot topics. For doctoral students and new faculty, there is a doctoral consortium and an early career workshop. There are also opportunities for software demos and other interactive events. And of course there are receptions and other social events to give extra times for people to get to know each other.

Although the CSCL community always had a strong base in Western Europe—partially associated with the AI and Education community—the first official CSCL conferences were held in North America. In 2001, a Euro-CSCL conference was organized in the Netherlands, attracting mainly European researchers. In 2002, the conference in the US achieved a good balance of European and American researchers; it initiated a policy of rotating the conferences to Europe (in 2003 and 2009), Asia (in 2005 and 2011) and North America (in 2007 and 2013). The conference in Taipei (2005) succeeded in achieving a good balance of paper authors, program committee members and conference participants from Western Europe, North America and the Asia-Pacific region.

Internationalization has always been a goal of the CSCL community. An analysis of trends during the first decade of the conferences documented strong progress in that direction (Kienle & Wessner, 2006). Analysis of authors included in the CSCL 2011 main conference shows approximately equal participation from Western Europe, North America and Asia-Pacific. Another important trend is an increase in the number of international collaborations in research and in the co-authorship of papers reporting on that research. Such collaboration is necessary for the spread of expertise and deep understanding of innovative ideas, methods and tools. This year's post-conference activities are an additional opportunity to promote exchange with researchers, practitioners and policy makers in Mainland China, an important area in which CSCL approaches seem to be spreading rapidly.

Of course, there are still major regions of the world under-represented in the CSCL community, such as the Middle East, Eastern Europe, Central Asia, South America and Africa. To some extent this may be due to limited traditions of collaborative learning or relatively low levels of computerization in schools in those areas. It may also be due to limitations in resources for traveling to international conferences or in awareness of the field. We have seen that strong involvement in CSCL research generally requires policy initiatives backed up with funding commitments. The European Union Network of Excellence funding programs like Kaleidoscope and Stellar have made a significant difference. NSF support for educational research has helped in the USA as well. Case studies elsewhere underline this factor (Chan, 2011; Looi et al., 2011).

A Delphi survey of researchers and stakeholders in technology-enhanced learning recently ranked CSCL as the second most important core research area for the next decade—just behind “connection between informal and formal learning” and ahead of nine other areas, like “personalized learning” (Kaendler et al., these Proceedings, Vol. II). We hope this recognition will spread around the world. In order to address the challenges facing CSCL in the coming years—not least of which are those related to practice and policy—we need the combined efforts of a global collaborative effort. Such an effort would bring together the unique perspectives of many labs and diverse educational cultures, acknowledging and strengthening their individual perspectives while incorporating them into a global synthesis.

Volume I: CSCL 2011 Long Papers

Volume I of the Proceedings includes the papers that were accepted through peer review for presentation as long papers. These papers were submitted in November 2010 and were reviewed by three anonymous reviewers. A member of the Program Committee then summarized the three reviews and wrote a recommendation. The three Program Committee Co-Chairs considered the reviews and recommendations—and in many cases read the papers. Based on this, they agreed on a list of 72 submissions to accept as long papers, grouping them into 18

sets of 4 thematically related papers that could be presented in the scheduled long-paper sessions. Out of 188 submissions of long papers, 72 (38%) were accepted as long papers, 45 (24%) as short papers, 48 (26%) as posters and 23 (12%) were rejected.

Volume II: CSCL 2011 Short Papers and Posters

Volume II of the Proceedings includes the papers that were accepted through peer review for presentation as short papers or posters. Submissions for short papers or posters went through exactly the same review process as long papers. Out of 52 submissions of short papers, 17 (33%) were accepted as short papers, 26 (50%) as posters and 9 (17%) were rejected. Out of 38 submissions of posters, 26 (68%) were accepted as posters and 12 (32%) were rejected. Short papers were grouped into sets of 6 thematically related papers. Authors of short papers give very brief presentations and then conduct round-table discussions of their papers with interested audience members. Posters were assigned to two poster sessions; authors of posters hang large-scale posters on walls and then discuss them with interested audience members.

Volume III: CSCL 2011 Pre-Conference, Keynotes, Symposia and Post-Conference

Volume III of the Proceedings includes summaries of other events at CSCL 2011.

The pre-conference events include workshops, tutorials, a Doctoral Consortium and an Early Career Workshop. There are three tutorials on tool support for analysis, social network analysis and the WISE environment. There are four workshops on orchestrating CSCL in the classroom, connecting levels of learning and synthesizing three approaches to CSCL design.

The highlights of this year's conference include keynote talks by prominent speakers: Dr. Gwang-Jo Kim, Director of UNESCO Regional Bureau for Education in Asia-Pacific; Dr. Ed H. Chi, Research Scientist, Google Research; Prof. Erik Duval, Professor of Computer Science, Katholieke Universiteit Leuven, Belgium; and Prof. Roy Pea, Stanford University Professor of the Learning Sciences and Director of the Stanford Center for Innovations in Learning. The keynotes cover the full range of issues from researcher, policy-maker and practice perspectives.

Out of 17 proposals for symposia, 14 (82%) were accepted and 3 (18%) were rejected. This high acceptance rate of symposia is a result of the fact that most of them had been carefully filtered by large groups of organizers. The submissions were generally of exceptional quality and represented important and timely themes that are of current high relevance to the field. They often reflect important centers of CSCL research in different regions of the world or international collaborations. In order to avoid having these symposia draw audiences away from long and short paper sessions, the symposia were mostly scheduled against each other.

The practitioner-oriented sessions take place in parallel with the paper and symposium sessions of the main conference. They include a wide variety of presentations and events that are designed for classroom teachers and others particularly interested in the applications of CSCL research and their use in the classroom. This strand of activities showcases design research in CSCL involving field-based educators and/or strong university-school partnerships. These events are of interest and benefit to teachers and other practitioners, as well as researchers and educators interested in models and exemplars of research and practice interaction and partnership. They are listed in the conference Program.

The post-conference consists of a series of conference activities to be held in Shanghai, Guangzhou and Beijing in China. It builds on the conference theme of connecting CSCL research to education policy and practice. It draws on national and global exemplars of synergistic advances in CSCL and learning sciences research and educational policy and practice to explore the current state and the way forward for education developments in China. This series of post-conference activities brings together researchers, practitioners and policy-makers within China and internationally to identify ways to better leverage the potentials that research on learning and learning technologies bring to educational change and improvement.

Hong Kong University Centenary

The CSCL 2011 conference coincides with a major local milestone as well as an advance of the CSCL community. A century ago, in 1911, the University of Hong Kong was incorporated by Ordinance. A group of visionaries founded the first university in Hong Kong, from which generations of leaders across the region would come forth. The University of Hong Kong was to be important for China and for the world. In celebrating the first centenary, HKU upholds its commitment to Knowledge, Heritage and Service. The Centre for Information Technology in Education (CITE) of the Faculty of Education is proud to be hosting the CSCL 2011 main conference and co-organizing the CSCL 2011 post-conferences in three Mainland Chinese cities as part of the HKU Centenary celebration events.

References

- Chan, C. (2011). CSCL theory-research-practice synergy: The Hong Kong experience of implementing knowledge building in classrooms. *International Journal of Computer-Supported Collaborative Learning*, 6(2). Doi: <http://dx.doi.org/10.1007/s11412-011-9121-0>.
- Kienle, A., & Wessner, M. (2006). The CSCL community in its first decade: Development, continuity, connectivity. *International Journal of Computer-Supported Collaborative Learning*, 1(1), 9-33. Doi: <http://dx.doi.org/10.1007/s11412-006-6843-5>.
- Looi, C.-K., So, H.-j., Toh, Y., & Chen, W. (2011). CSCL in classrooms: The Singapore experience of synergizing policy, practice and research. *International Journal of Computer-Supported Collaborative Learning*, 6(1), 9-38. Doi: <http://dx.doi.org/10.1007/s11412-010-9102-8>.

Table of Contents

Conference Organizers and Supporting Organization	i
Conference Sponsors	i
Steering Committee	ii
Local Organizing Committee	iii
Reviewers of CSCL2011 Conference	v
Introduction to the Proceedings of CSCL 2011	ix
Table of Contents	xiii

VOLUME I: LONG PAPERS

VOLUME I PART 1: KNOWLEDGE BUILDING

1. Construction of health knowledge in an alternative medical community of practice: Hermeneutic analysis of a web forum <i>Joachim Kimmerle, Kristina Abels, Katharina Becher, Anna Beckers, Annette Haussmann, Ansgar Thiel, Ulrike Cress</i>	1
2. Learning Science through Knowledge-Building and Augmented Reality in Museums <i>Susan Yoon, Karen Elinich, Christopher Steinmeier, Joyce Wang, Sean Tucker</i>	9
3. Beyond Small Groups: New Opportunities for Research in Computer-Supported Collective Learning <i>Yasmin Kafai, Kylie Peppler</i>	17
4. Visualisations for longitudinal participation, contribution and progress of a collaborative task at the tabletop <i>Roberto Martinez, Judy Kay, Kalina Yacef</i>	25
5. Questioning and the Quality of Knowledge Ideas in a CSCL Context: A Study on Two Age-groups of Students <i>Ming Lai, Nancy Law</i>	33
6. Location-based Collaborative Learning at a Geography Trail: Examining the Relationship among Task Design, Facilitation and Discourse Types <i>Esther Tan, Hyo-Jeong So</i>	41
7. Principle-Based Design for Collective Growth: From Knowledge Sharing to Explanatory Knowledge-Building Discourse <i>Carol Chan, Ella Fu</i>	49
8. Does Contributing to a Knowledge Building Dialogue Lead to Individual Advancement of Knowledge? <i>Maria Chuy, Jianwei Zhang, Monica Resendes, Marlene Scardamalia, Carl Bereiter</i>	57
9. Knowledge Construction Patterns in Online Conversation: A Statistical Discourse Analysis of a Role-Based Discussion Forum <i>Alyssa Friend Wise, Ming Ming Chiu</i>	64

10. Quantified Measures of Online Discourse as Knowledge Building Indicators <i>Jianwei Zhang, Yanqing Sun</i>	72
11. Critical Moments of Knowledge Co-construction: Reconsidering Meaning-making of Postings in Online Group Discussion <i>Hsiu-Mei Chang, Fei-Ching Chen, Kai-Tien Cheng, Ren-Yow Tzeng</i>	80
12. Towards an Understanding of "Listening" in Online Discussions: A Cluster Analysis of Learners' Interaction Patterns <i>Alyssa Friend Wise, Farshid Marbouti, Jennifer Speer, Ying-Ting Hsiao</i>	88
13. Socially constructive interaction for fostering conceptual change <i>Moegi Saito, Naomi Miyake</i>	96
14. Effects of Using Multiple Forms of Support to Enhance Students' Collaboration during Concept Mapping <i>Anushree Bopardikar, Dana Gnesdilow, Sadhana Puntambekar</i>	104
15. Weblines: Enabling the Social Transfer of Web Search Expertise using User-Generated Short-form Timelines <i>Neema Moraveji, Salman Ahmad, Chigusa Kita, Frank Chen, Sep Kamvar</i>	112
16. Facilitating Web Design Skills through Online Design-Based Learning: The Case of Collaboration Scripts and Incomplete Concept Maps <i>Walid El-Refai, Ingo Kollar, Frank Fischer</i>	120

VOLUME I PART 2: LEARNING ACTIVITIES AND TOOLS

1. Collaborative writing: too much of a good thing? Exploring engineering students' perceptions using the Repertory Grid <i>Anindito Aditomo, Rafael Calvo, Peter Reimann</i>	128
2. The Interactional Organisation of Location-based Gaming <i>Jo Dugstad Wake, Frode Guribye, Barbara Wasson</i>	136
3. Analysis of Small Group Interactions in a Seamless Language Learning Environment: An Artifact-Oriented Approach <i>Lung-Hsiang Wong, Wenli Chen, Ying Zhan, Chee-Kuen Chin</i>	144
4. Digital Media in the Classroom: A Study on How to Improve Guidance for Successful Collaboration and Learning in Student Teams <i>Carmen Zahn, Karsten Krauskopf, Friedrich W. Hesse, Roy Pea</i>	152
5. Weather Gods and Fruit Kids — Embodying abstract concepts using tactile feedback and Whole Body Interaction <i>Carolina Johansson, Zeynep Ahmet, Jakob Tholander, Franc Aleo, Martin Jonsson, Saiful Sumon</i>	160
6. Improving the mCSCL Approach of a Mobile Chinese Character Forming Game via a Design-based Research Cycle <i>Lung-Hsiang Wong, Ivica Boticki, Jizhen Sun, Chee-Kit Looi</i>	168
7. NumberNet: Using Multi-Touch Technology to Support Within and Between-Group Mathematics Learning <i>Andrew Hatch, Steve Higgins, Andrew Joyce-Gibbons, Emma Mercier</i>	176
8. Collaborative Gaze Footprints: Correlates of Interaction Quality <i>Patrick Jermann, Dejana Mullins, Marc-Antoine Nüssli, Pierre Dillenbourg</i>	184
9. Training in Virtual Training Environments: Connecting Theory to Practice <i>Johannes Moskaliuk, Johanna Bertram, Ulrike Cress</i>	192
10. Analyzing discourse synthesis - use of semantic information for collaborative writing in secondary education <i>Crina Damsa, Gijsbert Erkens, Jeroen Janssen</i>	200

- | | |
|---|-----|
| 11. Online Role Play Simulation to tackle Groupthink — Case study of a crisis management training | 208 |
| <i>Lawrence LEUNG, Nancy LAW</i> | |
| 12. Play and Augmented Reality in Learning Physics: The SPASES Project | 216 |
| <i>Noel Enyedy, Joshua Danish, Girlie Delacruz, Melissa Kumar, Sylvia Gentile</i> | |

VOLUME I PART 3: LEARNING INTERACTIONS

- | | |
|---|-----|
| 1. Group Sense Making of Multiple Sources in a Hypertext Environment | 224 |
| <i>Sarah Sullivan, Katherine Knight, Sadhana Puntambekar</i> | |
| 2. Formulating WISE Learning Experiences | 232 |
| <i>Vanessa Svihla</i> | |
| 3. Students Producing Thick Descriptions | 240 |
| <i>Richard Alterman, Johann Larusson</i> | |
| 4. Technology for Supporting Learners in Out-of-School Learning Environments | 248 |
| <i>Tamara Clegg, Christina Gardner, Janet Kolodner</i> | |
| 5. How a Virtual Math Team Structured its Problem Solving | 256 |
| <i>Gerry Stahl</i> | |
| 6. Constructing Part-task Congruent Representations to Support Coordination of Collaborative Problem-solving Tasks | 264 |
| <i>Bert Slof, Gijsbert Erkens, Paul A Kirschner</i> | |
| 7. Virtual Mathematical Inquiry: Problem Solving at the Gestural — Symbolic Interface of Remote-Control Embodied-Interaction Design | 272 |
| <i>Dragan Trninic, Jose Gutierrez, Dor Abrahamson</i> | |
| 8. How are students' problems being solved? The quality of worked solutions on a popular open, online, mathematics, help forum | 280 |
| <i>Carla van de Sande</i> | |
| 9. Fostering Representational Competence Through Argumentation with Multi-Representational Displays | 288 |
| <i>Mike Stieff</i> | |
| 10. Guiding the Process of Argumentation: The Effects of Ontology and Collaboration | 296 |
| <i>Frank Loll, Niels Pinkwart</i> | |
| 11. The Role of Argumentation for Domain-Specific Knowledge Gains in Computer-Supported Collaborative Learning: A Meta-Analysis | 304 |
| <i>Christof Wecker, Frank Fischer</i> | |
| 12. Technology and Dialogic Space: Lessons from History and from the 'Argunaut' and 'Metafora' Projects | 312 |
| <i>Rupert Wegerif, Yang Yang</i> | |
| 13. The Relationships among Online Question-Generation, Peer-Assessment and Academic Achievement | 319 |
| <i>Fu-Yun Yu, Chun-Ping Wu</i> | |
| 14. Using a Reflection Tool to Increase Reliability of Peer Assessments in a CSCL Environment | 326 |
| <i>Chris Phielix, Frans Prins, Jeroen Janssen, Paul Kirschner</i> | |
| 15. Adaptive support for CSCL: Is it feedback relevance or increased student accountability that matters? | 334 |
| <i>Erin Walker, Nikol Rummel, Kenneth R. Koedinger</i> | |

VOLUME I PART 4: TECHNOLOGY-ENHANCED INTERACTIONS AND ANALYSIS

1. Mind the gap: Differences between the aspirational and the actual in an online community of learners 342
Karen Brennan
2. Supporting Collaborative Learning in Recitation Sections Using an Ambient Awareness Tool 350
Hamed Alavi, Pierre Dillenbourg
3. Group Awareness Tools for Controversial CSCL Discussions: Dissociating Rating Effects and Visualized Feedback Effects 358
Jürgen Buder, Daniel Bodemer
4. Missing Something? Authority in Collaborative Learning 366
Iris Howley, Elijah Mayfield, Carolyn P. Rose
5. Fostering Social Navigation and Elaboration of Controversial Topics with Preference-Inconsistent Recommendations 374
Christina Schwind, Jurgen Buder, Friedrich W. Hesse
6. Adaptable Scripting in Computer-Supported Collaborative Learning to Foster Knowledge and Skill Acquisition 382
Xinghua Wang, Ingo Kollar, Karsten Stegmann, Frank Fischer
7. Explaining the Effects of Continuous and Faded Scripts on Online Search Skills: The Role of Collaborative Strategy Practice 390
Christof Wecker, Ingo Kollar, Frank Fischer
8. Conversational Strategies that Support Idea Generation Productivity in Groups 398
Rohit Kumar, Jack Beuth, Carolyn Rose
9. The Myth of Over-scripting: Can Novices be Supported too much? 406
Karsten Stegmann, Jin Mu, Vera Gehlen-Baum, Frank Fischer
10. A Scaffolded Software Tool for L2 Vocabulary Learning: GroupScribbles with Graphic Organizers 414
Wenli Chen, Chee Kit Looi, Yun Wen
11. Orchestrating Web-Based Collaborative Inquiry Learning with Small Group and Classroom Scripts 422
Ingo Kollar, Christof Wecker, Sybille Langer, Frank Fischer
12. Scripting Collaborative Learning in Smart Classrooms: Towards Building Knowledge Communities 430
Michelle Lui, Mike Tissenbaum, James D. Slotta
13. ACODEA: A Framework for the Development of Classification Schemes for Automatic Classifications of Online Discussions 438
Jin Mu, Karsten Stegmann, Elijah Mayfield, Carolyn Rose, Frank Fischer
14. Rating dimensions of collaboration quality in synchronous collaborating dyads: findings and interpretations 446
Georgios Kahrmanis, Irene-Angelica Chounta, Nikolaos Avouris
15. Technological affordances for productive multivocality in analysis 454
Gregory Dyke, Kristine Lund, Heisawn Jeong, Richard Medina, Daniel D. Suthers, Jan van Aalst, Wenli Chen, Chee-Kit Looi
16. The automatic assessment of knowledge integration processes in project teams 462
Gahgene Gweon, Pulkit Agrawal, Mikesh Udani, Bhiksha Raj, Carolyn Rose

VOLUME I PART 5: ISSUES IN CSCL

- | | |
|--|-----|
| 1. Learning Through Collaborative Creation of Knowledge Objects in Teacher Education
<i>Crina Damsa, Sten Ludvigsen</i> | 470 |
| 2. Assessing the use of a Trace-Based Synchronous Tool for distant language tutoring
<i>Mireille Betrancourt, Nicolas Guichon, Yannick Prié</i> | 478 |
| 3. A collaborative platform supporting knowledge sharing and problem solving for teacher professional development
<i>Thierry Condamines</i> | 486 |
| 4. Interactive Representations of Student Activity to Inform Teacher Collaborations: Results from a Formative Exploration
<i>R. Benjamin Shapiro, Peter Wardrip</i> | 494 |
| 5. Unfolding experienced teachers' pedagogical practices in technology-enhanced collaborative learning
<i>Minna Lakkala, Liisa Ilomaki</i> | 502 |
| 6. Classroom orchestration: The third circle of usability
<i>Pierre Dillenbourg, Guillaume Zufferey, Hamed Alavi, Patrick Jermann, Son Do-Lenh, Quentin Bonnard, Sebastien Cuendet, Frederic Kaplan</i> | 510 |
| 7. Mind the Gaps: Using Patterns to Change Everyday Classroom Practice Towards Contingent CSCL Teaching
<i>Luis P. Prieto, Sara Villagra-Sobrino, Yannis Dimitriadis, Patricia Schank, William Penuel, Angela Haydel DeBarger</i> | 518 |
| 8. Learning Design as a Medium for Scaffolding Teacher Learning and Collaboration
<i>Nancy Law, Diana Laurillard, Yeung Lee</i> | 526 |
| 9. Seeing what we mean: Co-experiencing a shared virtual world
<i>Gerry Stahl, Nan Zhou, Murat Perit Cakir, Johann Sarmiento-Klapper</i> | 534 |
| 10. Is CSCL the missing link between education and the 21st century economy?
<i>Jeremy Roschelle, Charles Patton, Yukie Toyama</i> | 542 |
| 11. A Portrait of CSCL Methodologies
<i>Heisawn Jeong, Cindy Hmelo-Silver</i> | 550 |
| 12. Technology-mediated reflection and peer-exchange: Supports for teacher professional development communities
<i>Cheryl Ann Madeira, James D. Slotta</i> | 558 |

AUTHOR INDEX

xxxi-xxxvi

(END OF VOLUME I)**VOLUME II: SHORT PAPERS & POSTERS****VOULME II PART 1: KNOWLEDGE BUILDING**

- | | |
|--|-----|
| 1. Divergent and Convergent Knowledge Processes on Wikipedia
<i>Iassen Halatchliyski, Joachim Kimmerle, Ulrike Cress</i> | 566 |
| 2. Evaluation by Grade 5 and 6 Students of the Promisingness of Ideas in Knowledge-Building Discourse
<i>Bodong Chen, Maria Chuy, Monica Resendes, Marlene Scardamalia, Carl Bereiter</i> | 571 |

3.	Characterizing Knowledge Building Discourse <i>Jennifer Yeo, Jing Wu</i>	576
4.	Some Discourse Mechanisms for Knowledge Advancement in a CSCL Context <i>Ming Lai, Nancy Law</i>	581
5.	Dimensions of Social Interactions Contributing to Knowledge Construction and Building in an Online Learning Community <i>Victor Law, Xun Ge, Deniz Eseryel</i>	586
6.	Context Aware CSCL: Moving Toward Contextualized Analysis <i>Sean P. Goggins, James Laffey, Chris Amelung</i>	591
7.	Capturing and analysing the processes and patterns of learning in collaborative learning environments <i>Kate Thompson, Shannon Kennedy-Clark, Lina Markauskaite, Vilaythong Southavilay</i>	596
8.	Social Skills as Predictors of Satisfaction and Performance in a Project-based Learning CSCL Environment: An Empirical Study <i>Michele P. Notari, Adrian Baumgartner</i>	601
9.	Seven Challenges in CSCL <i>Ravi Vatrappu</i>	606
10.	Retelling Stories: Setting Learner Narratives in Resource Ecologies <i>Joshua Underwood, Rosemary Luckin, Niall Winters</i>	611

VOLUME II PART 2: LEARNING ACTIVITIES AND TOOLS

1.	Case-based learning in a virtual professional training — Collaborative problem solving activities and outcomes <i>Birgitta Kopp, Melanie Hasenbein, Heinz Mandl</i>	616
2.	Online Smart "Discussion Forum" — An environment for an Effective Task-based Collaborative Discussion among the Adult Learners <i>Nantha Kumar Subramaniam, Abdullah Mohd Zin, Sufian Idris</i>	621
3.	Collaborating in a Virtual Engineering Internship <i>Cynthia D'Angelo, Golnaz Arastoopour, Naomi Chesler, David Williamson Shaffer</i>	626
4.	Designing, orchestrating and evaluating inter-professional collaboration in a scripted 3D learning space for vocational education <i>Raija Hamalainen, Kimmo Oksanen</i>	631
5.	Learning with Prediction Markets: An Experimental Study <i>Cali Ellis, Rahul Sami</i>	636
6.	Co-design of Collaborative Collective Knowledge Environment <i>Elizabeth S. Charles, Mike Tissenbaum, Chris Whittaker, Michelle Lui, Michael Dugdale, James D. Slotta</i>	641
7.	Utilizing a collaborative "Cross Number Puzzle" game on Group Scribbles to develop students' computing ability of addition and subtraction <i>Yen-Hua Chen, Tak-Wai Chan, Chee-Kit Looi, Yin-Juan Shao, Chiu-Pin Lin</i>	646
8.	Taking Educational Games to the Afterschool: Teens and Researchers on a Quest in Collaborative Design-Based Research <i>Jacob Dayan, Yael Kali</i>	651
9.	Enhancement Effects of Online Edutainment Game-Play on Students' Scholastic Achievements in English and Mathematics <i>Diane Hui, Anthony R. Dickinson</i>	656
10.	How a New Actor Was Temporarily Enrolled Into the Network of Game Playing <i>Mark Chen</i>	661
11.	Allocentrism and Computational Thinking <i>Carmen Petrick, Matthew Berland, Taylor Martin</i>	666

12. When a console game becomes CSCL: Play, participatory learning and 8-bit home computing in India 671
Derek Lomas, Dixie Ching, Christopher Hoadley, Kishan Patel, Matt Kam

VOLUME II PART 3: LEARNING INTERACTIONS

1. Emerging Tensions in the Future of Technology-Enhanced Learning: First Results of an International Delphi Study 676
Celia Kaendler, Christine Plesch, Anne Deiglmayr, Dejana Mullins, Nikol Rummel, Hans Spada
2. An Integrated Approach for the Enactment of Collaborative Pedagogical Scripts Using Mobile Technologies 681
Marcelo Milrad, Dan Kohen-Vacs, Bahtijar Vogel, Miky Ronen, Arianit Kurti
3. The design and investigation of a web-based synchronous and asynchronous peer feedback mechanism 686
Eleni A. Kyza, Georgia Michael, Costas P. Constantinou
4. An Execution Semantics to Support Flexibility in Collaborative Learning Scripts 691
Roberto Perez-Rodriguez, Manuel Caeiro-Rodriguez
5. PeerSpace: An Online Peer Collaborative Learning Environment for First Year Computer Science Students 696
Cen Li, Zhijiang Dong, Roland Untch, Nathan Reale, Michael Chasteen
6. The Role of Different Narratives in Recognizing Peer Expertise in Collaborative Programming Projects 701
Deborah Fields, Yasmin Kafai
7. Collaborative Problem Solving Processes in a Scenario-Based Multi-User Environment 706
Shannon Kennedy-Clark, Kate Thompson, Debbie Richards
8. Factors Contributing to Learners' Online Listening Behaviors in Online and Blended Courses 711
Alyssa Friend Wise, Jennifer Speer, Ying-Ting Hsiao, Farshid Marbouti
9. Supporting Argumentative Knowledge Construction in Face-to-Face Settings: From ArgueTable to ArgueWall 716
Sara Streng, Karsten Stegmann, Christine Wagner, Sonja Bohm, Frank Fischer, Heinrich Hussmann
10. Coding schemes as measurement instruments? An attempt to assess the psychometric properties of a coding scheme 721
Andri Ioannou, Agni Georgiou, Elena Papanastasiou
11. Collaboration in communities of inquirers: an example from a geography field trip 726
Eileen Scanlon, Canan Blake, Alison Twiner, Trevor Collins, Ann Jones, Lucinda Kerawalla
12. Exploring Joint Attention around Shared Referential Anchors during Physical, Virtual and Mixed Reality Laboratory Activities 731
Garrett Smith, Anushree Bopardikar, Sadhana Puntambekar

VOLUME II PART 4: TECHNOLOGY-ENHANCED INTERACTIONS & ANALYSIS

1. E-Tutorial Support for Collaborative Online Learning: Differences between experienced and non-experienced E-tutors 736
Birgitta Kopp, Maria Cristina Matteucci, Carlo Tomasetto, Heinz Mandl

2. The impact of interaction analysis graphs on groups during online collaboration through blogs according to the "learning by design" scenario 741
Georgios Fesakis, Angelique Dimitracopoulou, Aggelos Palaiodimos
3. Video Analysis of Learners' Interactions with the Expert: Using Mobile Devices as Mediating Tools for Learning at a Museum 746
Susanna Mann, Peter Reimann
4. Multiple modes of scaffolding to enhance web-based inquiry 751
Annelies Raes, Tammy Schellens, Bram De Wever, Ellen Vanderhoven
5. Social Annotating in the Online Margins: Re(designing) an Annotation Tool drawing on Unintended Ways University Students and Faculty Chose to Use It 756
Eva Bures, Andrew Feenberg, Cindy Xin, Philip Abrami
6. Supporting Collaborative Interaction with Open Learner Models: Existing Approaches and Open Questions 761
Susan Bull, Ravi Vatrappu
7. Trustworthy in the Eye of the Beholder? — A Cognitive Perspective on Personal Profile Information in Virtual Project Teams 766
Ellen Rusman, Jan van Bruggen, Peter Sloep, Rob Koper, Martin Valcke
8. Detecting Collaboration Regions in a Chat Session 771
Dan Banica, Stefan Trausan-Matu, Traian Rebedea
9. Social Cues in Asynchronous Online Discussions: Effects of Social Metacognition and New Ideas 776
Gaowei Chen, Ming Ming Chiu, Zhan Wang
10. PolyCAFe: Collaboration and Utterance Assessment for Online CSCL Conversations 781
Mihai Dascalu, Traian Rebedea, Stefan Trausan-Matu, Gillian Armit
11. Analysis of Group Understanding in Artifact-Mediated Discourses 786
Heisawn Jeong, Wenli Chen, Chee Kit Looi
12. Investigating Students' Epistemologies in CSCL discourse through Reflective Judgment Model and Practical Epistemologies 791
Johnny Yuen

VOLUME II PART 5: ISSUES IN CSCL

1. Recommender Systems: A Technology to Foster Individual and Collaborative Learning 796
Jürgen Buder, Christina Schwind
2. Support by Educators for Knowledge Building in an Organic Social Networking Environment 801
David James Woo
3. Group Meaning in Mathematical Discourse: A Multimodal Analysis of PreK Students Using Multi-Touch Virtual Manipulatives 806
Michael A. Evans, Jesse L.M. (Jay) Wilkins, Andrea Motto, Adrienne Brunger, Jeremy Crider
4. Privacy, Trust and the Practice of Learning Management Systems 811
Kai-Uwe Loser, Thomas Herrmann
5. Virtual Social Competence Instruction for Individuals with Autism Spectrum Disorders: Beyond the Single-User Experience 816
Matthew Schmidt, James Laffey, Janine Stichter
6. Teachers' interventions and Knowledge Creation in a Master 'Learning & Innovation for Teachers in Vocational Education' 821
Frank de Jong, Hennie van Heijst, Lia Spreeuwenberg, Hanneke de Laat

7. Using Online Communication Tools to Mediate Curriculum Development As A Collaborative Process 826
Lei Liu, Susan Yoon
8. Bridging Multiple Expertise in Collaborative Design for Technology-Enhanced Learning 831
Yael Kali, Lina Markauskaite, Peter Goodyear, Mary-Helen Ward
9. Towards a model for rapid collaborative knowledge improvement in classroom language learning 836
Yun Wen, Chee-Kit Looi, Wenli Chen
10. Tabletops for Collaborative Learning: A Case Study on Geometry Learning at the Primary School 841
Gustavo Salvador-Herranz, David Perez-Lopez, Mario Ortega, Mariano Alcaniz, Manuel Contero
11. Productive re-use of CSCL data and analytic tools to provide a new perspective on group cohesion 846
Christophe Reffay, Christopher Teplovs, Francois-Marie Blondel
12. Expert Participation in Elementary Students' Collaborative Design Process 851
Kaiju Kangas, Pirita Seitamaa-Hakkarainen

VOLUME II POSTERS

1. Online Communication and Collaboration in a Community of Practice for Teachers Professional Development 856
Gyeong Mi Heo, Alain Breuleux
2. Students changing their conceptions of collaboration through computer-supported knowledge building 858
Yu-Hui Chang, Huang-Yao Hong, Pei-Chen Tsai, Po-Hsien Wang
3. Location-based language learning: Bridging Theory and Practice 860
Armanda Lewis
4. Hidden Structures in Asynchronous Course Forums: Toward a Golden Ratio Population Parameter 862
Paul Gorsky
5. Patterns as Facilitators for Knowledge Building in Learning Organizations 864
Christina Matschke, Johannes Moskaliuk, Franziska Arnold, Ulrike Cress
6. Exploring the Role of Technology-Supported Peer Instruction in Student Understanding and Interaction in College Physics Classrooms 866
Elizabeth Charles, Jonghwi Park, Chris Whittaker, Nathaniel Lasry
7. Collaboration at Scale: How and Why are Instructors Using Collaborative Learning Management System Tools? 868
Andrew Krumm, Richard Waddington, Steven Lonn, Stephanie Teasley
8. Fostering Critical Thinking in Science Museums through Digital Augmentations 870
Susan Yoon, Karen Elinich, Joyce Wang, Christopher Steinmeier, Jackie Van Schooneveld
9. Investigating Different Critical Thinking Tests in an Authentic Inquiry 872
Jing Leng
10. The development of life transition skills in Inter-Life: a novel, 3-dimensional virtual learning environment 874
Alison Devlin, Vic Lally, Madeleine Sclater, Karla Parussel
11. How Do Instructors Design Classroom-wide Interactive Formative Assessments? A Field Study with 18 Schools 876
Neema Moraveji, Roy Pea

12. Patterns of Collaborative Convergence in a Scenario-Based Multi-User Virtual Environment 878
Shannon Kennedy-Clark, Kate Thompson
13. Diagnosable Concept Map toward Group Formation and Peer Help 880
Tsukasa Hirashima, Kazuya Yamasaki, Hiroyuki Fukuda, Hideo Funaoi
14. OASIS: Designing CSCL to support argumentation 882
Jingyan Lu, Nancy Law, Liping Deng, Yeung Lee
15. SECI-driven problem-based learning for cultivating technological pedagogical content knowledge 884
Meng Yew Tee, Shuh Shing Lee
16. Parcours - Teaching Primary School Children Logical Thinking and Coordination skills through a Collaborative Smart Table Game 886
Patrick Dohrmann, Niels Pinkwart, Andreas Rausch, Alke Jurgens, Tim Warnecke
17. Dialogic Framework for Creative and Collaborative Problem-solving 888
Deller Ferreira, Rupert Wegerif
18. DESIGN STUDY ON ALGEBRA REFORM: A GENSING PROJECT 890
Sarah Davis, Suzanne Nelson, David Effendi
19. Can participation and procrastination in discussion forums predict project performance in computer science courses? 892
Jaebong Yoo, Erin Shaw, Jihie Kim
20. Enhancing Computer-Supported Case-Based Learning for Pre-Service Teachers: Effects of Hyperlinks to Conceptual Knowledge and Multiple Perspectives 894
Jan Zottmann, Frank Fischer, Annika Goeze, Josef Schrader
21. Vegetation Interaction Game: Digital SUGOROKU to Learn Vegetation Succession for Children 896
Akiko Deguchi, Fusako Kusunoki, Shigenori Inagaki, Etsuji Yamaguchi, Yoshiaki Takeda, Masanori Sugimoto
22. Discourse analysis of collaborative meaning making in CSCL 898
Shaoming Chai, Jianhua Zhao, Su Mu
23. Reflective practice on online collaborative learning and knowledge building in campus-based teacher education courses 900
Therese Laferriere, Christine Hamel, Stephane Allaire
24. Exploring Student Understanding of Complex Causality in an Ecosystems-Based Multi-User Virtual Environment 902
M. Shane Tutwiler, Tina Grotzer, Amy Kamarainen, Shari Metcalf, Chris Dede
25. Increasing International Capacity for CSCL: CoReflect, an Example of Sharing and Adapting CSCL Environments across Europe 904
Iris Tabak, Itay Asher, Samira Nasser, Eleni Kyza, Christothea Herodotou, Iolie Nicolaido, Andreas Redfors, Lena Hansson, Maria Rosberg, Cally Oldershaw, Constantinos Constantinou, Hans van der Meij, Sascha Schanze, Ulf Saballus, Vassilis Kollias
26. Experiencing, Conducting, Designing and Evaluating Polyphony in CSCL Chats 906
Stefan Trausan-Matu
27. GroupNotes: Encouraging Proactive Student Engagement in Lectures through Collaborative Note-taking on Smartphones 908
Mark Reilly, Haifeng Shen
28. Crafting Identities: E-Textile Artifacts as Mediators in High Tech Communities 910
Deborah Fields, Yasmin Kafai
29. Collaborative knowledge building for understanding science concepts 912
Pei-Chen Tsai, Huang-Yao Hong, Chieh-Hsin Chiu, Ming Hong

30. Design and Development of a Formative Assessment Tool for Knowledge Building and Collaborative Learning	914
<i>Jan van Aalst, Carol K. K. Chan, Yuen-Yan Chan, Wing-San Wan, Stella Tian</i>	
31. Live linking of fieldwork to the laboratory increases students inquiry based reflections	916
<i>Anne Adams, Tim Coughlan, Yvonne Rogers, Trevor Collins, Sarah Davies, Canan Blake, John Lea</i>	
32. Learning Technology by Collaborative Design and Evaluation	918
<i>Chun Hu, Wai Yat Wong, Vilma Fyfe</i>	
33. Learners' Ideas about Plate Tectonics and Collaborative Game Play	920
<i>Beaumie Kim, Xueli Wang, Mi Song Kim</i>	
34. Increasing anonymity in peer assessment using classroom response technology	922
<i>Annelies Raes, Tammy Schellens, Ellen Vanderhoven</i>	
35. It's not only words that constitute conversation — analyzing a collaboration process while reflecting	924
<i>Sarah Hundertmark, Sascha Schanze</i>	
36. Formative Evaluation of Activity Structures for a Middle School Climate Change Curriculum	926
<i>Vanessa Peters, Nancy Songer</i>	
37. A Web-based Doctoral Program to Develop Culturally Responsive Special Education Faculty	928
<i>Patricia Peterson, Stephen Showalter</i>	
38. Tabletop Teaching Simulation: Collaborative Multivoiced Simulation for Improving Lesson Plans in Pre-service Training	930
<i>Toshio Mochizuki, Hiroshi Sasaki, Yoshihiko Kubota, Hideyuki Suzuki</i>	
39. My-Pet-My-Quest:Using Authoring Tool in Open Content Environment to Extend Learning Quests	932
<i>Charles Y. C. Yeh, Zhi-Hong Chen, Calvin C. Y. Liao, Tak-Wai Chan</i>	
40. PreK Teachers & Students Using Multi-Touch Virtual Manipulatives: An Analysis of Usability and Learner-centered Design	934
<i>Michael A. Evans, Jeremy Crider, Andrea Motto, Adrienne Brunger, Jesse L.M. (Jay) Wilkins</i>	
41. Designing course management system into CSCL tools: Experience with Moodle	936
<i>Jingyan Lu, Nancy Law</i>	
42. Computer Support for Collaborative Reflection on Captured Teamwork Data	938
<i>Kristin Knipfer, Michael Prilla, Thomas Herrmann, Ulrike Cress</i>	
43. Factors affecting students' performance in a supportive e-learning system — eCIS: an exploratory study	940
<i>Ching-Huei Chen, I-Chia Wu</i>	
44. Expanding the role of design to support CSCL	942
<i>Daniel Spikol</i>	
45. A Supporting System for Pupils' Question-Posing and Peer-Assessment	944
<i>Zhi-Hong Chen, Euphony F. Y. Yang, Hsiu-Mei Chang, Chih-Mao Chen, Tak-Wai Chan</i>	
46. Orchestrating CSCL - More Than a Metaphor?	946
<i>Ingo Kollar, Raija Hamalainen, Michael A. Evans, Bram De Wever, Carlo Perrotta</i>	
47. Epistemic mediation, chronotope, and expansive knowledge practices	948
<i>Kai Hakkarainen, Giuseppe Ritella, Pirta Seitamaa-Hakkarainen</i>	
48. Upon the role of the teacher in the informal learning setting of an intercultural computer club	950
<i>Anne Weibert, Birgit Sander, Kai Schubert</i>	

49. Exploring new directions in teachers' professional development: Monitoring teachers' fidelity of implementation of (argumentative) dialogue <i>Reuma De-Groot</i>	952
50. Linking Genotypic And Phenotypic Ideas Of Evolution Through Collaborative Critique-focused Concept Mapping <i>Beat Schwendimann</i>	954
51. Distinguishing Evolution Ideas Through Two Different Forms Of Collaborative Critique-Focused Concept Mapping Activities <i>Beat Schwendimann</i>	956
52. Single- and Mixed-Gender Pairs' Help-Seeking and Domain-Knowledge Gains in Collaborative Inquiry-Learning Classroom <i>Kati Makitalo-Siegl, Frank Fischer, Carmen Kohnle</i>	958
53. Engaging Learners in the Identification of Key Ideas in Complex Online Discussions <i>Jim Hewitt, Clare Brett</i>	960
54. Does news value help learners sharing relevant information? <i>Anja Rudat, Jurgen Buder, Daniel Bodemer</i>	962
55. Scaling Dynamic Mathematics Reform: Findings from the SunBay Pilot Study <i>Charles Vanover, George Roy, Zafer Unal, Vivian Fueyo, Nicole Collier, Phil Vahey</i>	964
56. Visual Representations of Videotaped Interactions: Understanding Activity Patterns in the Classroom <i>Cheryl Ann Madeira, James D. Slotta</i>	966
57. Modeling Efficient Grounding in Chat-based CSCL: An Approach for Adaptive Scripting? <i>Michael Oehl, Hans-Ruediger Pfister</i>	968
58. Pearls of Wisdom: A Computational Scaffold for Design and Diffusion of Cognitive Artifacts <i>Robbin Chapman</i>	970
59. Making Meaning and Building Understanding Online: Designing an Innovative and Participative Assessment <i>Gabriel B. Reedy</i>	972
60. OASIS: An Online Professional Learning Community for Inquiry-based Teaching <i>Robbin Chapman, Shaundra Daily</i>	974
61. Towards the Identification of Emergent Strategies for Interdependent Collaboration in Complex Tasks <i>Daniel Greene, Paulo Blikstein</i>	976
62. GlobalEd 2: A Technology Mediated Simulation Targeted at Writing in the Disciplines <i>Kimberly Lawless, Scott Brown, Mark Boyer</i>	978
63. Developing Collaborative Argumentation Systems: What Advice Do the Experts Have? <i>Frank Loll, Niels Pinkwart, Oliver Scheuer, Bruce McLaren</i>	980
64. Learning about Ecosystems in a Computer Supported Collaborative Learning Environment <i>Sameer Honwad, Cindy Hmelo-Silver, Rebecca Jordan, Suparna Sinha, Catherine Eberbach, Ashok Goel, Spencer Rugaber</i>	982
65. Collaborative Learning with Scaffolded Dynamic Visualizations <i>Jennifer Chiu</i>	984
66. Improving Collaboration through Visibility of Students' Learning Products in a Digital Classroom Environment <i>Juan Carlos Hernandez, Luis Facundo Maldonado, Widman Said Valbuena, H. Ulrich Hoppe</i>	986

67. Explanatory Activity with a Partner Promotes Children's Learning from Multiple Solution Methods	988
<i>Miho Kawasaki, Hajime Shirouzu</i>	
68. Collaborative Design Process of a Rich Interactive Web-based Interprofessional Pain Education Resource	990
<i>Michelle Lui, Judy Watt-Watson, Leila Lax, Adam Dubrowski, Michael McGillion, Judith Hunter, Kerry Knickle, Cameron MacLennan, Anja Robb, Jaime Lapeyre</i>	
69. Talking Like a Composer: Negotiating shared musical compositions using Impromptu	992
<i>Michael Downton, Kylie Pepler, Jeanne Bamberger</i>	
70. Agreeing to Disagree: Challenges with Ambiguity in Visual Evidence	994
<i>Camillia Matuk, Elissa Sato, Marcia Linn</i>	
71. Facilitating Knowledge Communities in Science Classrooms through Scripted Collaboration	996
<i>Hedieh Najafi, Naxin Zhao, James Slotta</i>	
72. Ways of contributing to a knowledge-building dialogue in history	998
<i>Monica Resendes, Maria Chuy, Bodong Chen, Marlene Scardamalia</i>	
73. An Educational Perspective: Research Through Design	1000
<i>Heidrun Allert, Christoph Richter</i>	
74. An Analysis of Teacher-Students Interactions in Three Science Classes: A Pilot Study	1002
<i>Naxin Zhao, Hedieh Najafi, James Slotta</i>	
75. Advancing a Complex Systems Approach to Personalized Learning Communities: Bandwidth, Sightlines, and Teacher Creativity	1004
<i>Eric Hamilton</i>	
76. New forms of collaborative repository development involving students, teachers, and Japanese lesson study	1006
<i>Eric Hamilton</i>	

AUTHOR INDEX

xxxi-xxxvi

(END OF VOLUME II)**VOLUME III: KEYNOTES, SYMPOSIA, PRACTITIONER-ORIENTED EVENTS, PRE-CONFERENCE AND POST-CONFERENCE**

VOULME III PART 1: KEYNOTES	1008
1. Linking Research and Policy Practice Towards Quality Learning: Why and How?	1009
<i>Dr. Gwang-Jo KIM, Director of UNESCO Regional Bureau for Education in Asia-Pacific</i>	
2. Augmented Social Cognition: How Social Computing is Changing eLearning	1010
<i>Dr. Ed H. CHI, Research Scientist, Google Research</i>	
3. On the importance of being open...	1011
<i>Prof. Erik DUVAL, Professor of computer science, K.U.Leuven, Belgium</i>	
4. CSSL Opportunities and Challenges in the Context of the US National Educational Technology Plan	1012
<i>Prof. Roy PEA, Stanford University Professor of the Learning Sciences, and Director of the Stanford Center for Innovations in Learning</i>	

VOLUME III PART 2: SYMPOSIA	1013
1. ISLS presidential sessions: Honoring Janet Kolodner <i>Iris Tabak, Sadhana Puntambekar</i>	1014
2. Towards Productive Multivocality in the Analysis of Collaborative Learning <i>Daniel Suthers, Kristine Lund, Carolyn Rose, Gregory Dyke, Nancy Law, Chris Teplovs, Wenli Chen, Ming Ming Chiu, Heisawn Jeong, Chee Kit Looi, Richard Medina, Jun Oshima, Keith Sawyer, Hajime Shirouzu, Jan Willem Strijbos, Stefan Trausan-Matu, Jan van Aalst</i>	1015
3. Augmented Reality Games: Place-based Digital Learning <i>Eric Klopfer, Josh Sheldon, Louisa Rosenheck, Judy Perry, Kurt Squire, Jim Mathews, Bob Coulter, Matt Dunleavy, R. Benjamin Shapiro</i>	1023
4. Collaboration as Scaffolding: Learning Together with Dynamic, Interactive Scientific Visualizations and Computer Models <i>Marcia Linn, Ji Shen, Hsin-Yi Chang, Fang-Pei Hsieh, Beat Schwendimann, Camillia Matuk, Jennifer King Chen, Jennifer Chiu, Charles Xie, Baohui Zhang, Daner Sun, Karel Mous, Quee Boon Koh, Bahadia Namdar, Rutchelle Enriquez, Jing Lei, Heng Luo, Sunghye Lee, Hsin-Kai Wu</i>	1029
5. Contextualizing the changing face of Scaffolding Research: Are we driving pedagogical theory development or avoiding it? <i>Rosemary Luckin, Chee Kit Looi, Sadhana Puntambekar, Danae Stanton Fraser, Iris Tabak, Joshua Underwood, Wenli Chen</i>	1037
6. Introducing China: Expanding the CSCL Research Community <i>Jianhua Zhao, Kedong Li, Shaoming Chai, Lu Wang, Shaoqing Guo, Shengquan Yu, Gang Cheng, Xianmin Yang, Yanyan Li, Jianhua Zhao, Hui Xu, Xidiao Chen, Xiaoqing Gu, Jian Zhao, Xianqing Bao, Kangli Li, Jim Slotta, Nancy Law</i>	1045
7. A Principle-Based Approach to Knowledge Building: Processes, Challenges, and Implications <i>Jianwei Zhang, Marlene Scardamalia, Carol Chan, Jan van Aalst, Yuen Han Fung, Hidy Tse, Elizabeth Morley, Richard Messina, Janet Kolodner</i>	1053
8. Fostering Conceptual Change with Technology: Asian Perspectives <i>Chwee Beng Lee, David Jonassen, Seng Chee Tan, Naomi Miyake, Jan Van Aalst, Peter Reimann</i>	1059
9. MUPEMURE: Towards a Model of Computer-Supported Collaborative Learning with Multiple Representations <i>Daniel Bodemer, Manu Kapur, Gaele Molinari, Nikol Rummel, Armin Weinberger</i>	1065
10. CSCL and Innovation: In Classrooms, With Teachers, Among School Leaders, In Schools of Education <i>Jeremy Roschelle, Charlie Patton, Patricia Schank, William Penuel, Chee-Kit Looi, Wenli Chen, Anwar Chan, Luis Prieto, Sara Villagra-Sobrino, Yannis Dimitriadis</i>	1073
11. Embedding CSCL in Classrooms: Conceptual and Methodological Challenges of Research on New Learning Spaces <i>Jim Slotta, Mike Tissenbaum, Michelle Lui, Iyad Alagha, Elizabeth Burd, Steve Higgins, Emma Mercier, Frank Fischer, Florian Pilz, Ingo Kollar, Tom Moher, Alessandro Gnoli, Allison Jaeger, Jennifer Wiley, Brenda López Silva, Michael Evans, Andrea Motto, Adrienne Brunger, Jeremy Crider, Jay Wilkins</i>	1081
12. Strengthening the Conceptual Foundations of Knowledge Building Theory and Pedagogy <i>Katerine Bielaczyck, Kai Hakkarainen, Guiseppa Ritella, Pirita Seitamaa-Hakkarainen, Gerry Stahl, Marlene Scardamalia, Carl Bereiter</i>	1089

- | | |
|--|------|
| 13. Integrated tool support for learning through knowledge creation | 1095 |
| <i>Sten Ludvigsen, Crina Damsa, Hanni Muukkonen</i> | |
| 14. How Can Current Approaches to the Transfer of Technology-Based Collaboration Scripts for Research and Practice Be Integrated? | 1103 |
| <i>Karsten Stegmann, Christof Wecker, Andreas Harrer, Michaela Ronen, Dan Kohenvacs, Yannis Dimitriadis, Davinia Hernandez-Leo, Eloy Fernandez, Juan Asensio-Perez, Frank Fischer</i> | |
| 15. Enhancing the Social and Cognitive Benefits of Digital Tools and Media | 1111 |
| <i>Therese Laferriere, Marjut Viilo, Pirta Seitamaa-Hakkarainen, Kai Hakkarainen, Jun Oshima, Marlene Scardamalia, Carl Bereiter, Bodong Chen, Maria Chuy, Monica Resendes, Jan van Aalst, Carol Chan, Katerine Bielaczyc, Huang-Yao Hong, Jianwei Zhang</i> | |

VOLUME III PART 3: INTERACTIVE EVENTS, DEMONSTRATIONS AND CSCL IN PRACTICE SHOWCASES 1119

- | | |
|--|------|
| 1. Common boundary between different worlds: Collaboration between researchers and school teachers in NLC KB project in Singapore | 1120 |
| <i>Jennifer Yeo, Yew-Jin Lee, Jing Wu, S Zanariah Ahmad, Siew Kheng Cheong, Chor Miang Sim, Hsueh Chien Dawn Lee, Chong Wah Cedric Choy</i> | |
| 2. Getting started and sustaining Knowledge Building | 1123 |
| <i>Chuy Maria, Marlene Scardamalia, Carl Bereiter, Monica Resendes, Bodong Chen, Christian Tarchi, Richard Messina, Elizabeth Morley, Katerine Bielaczyc, Stian Håkklev, Jianwei Zhang</i> | |
| 3. Collaborative Virtual Worlds and Productive Failure: Design Research with Multi-disciplinary Pedagogical, Technical and Graphics, and Learning Research Teams | 1126 |
| <i>Michael Jacobson, Charlotte Taylor, Chun Hu, Anne Newstead, Wai-Yat Wong, Debbie Richards, Meredith Taylor, Iwan Kartiko, John Porte, Manu Kapur</i> | |
| 4. An Interactive Research Experience with Mobile Biology Games | 1130 |
| <i>Eric Klopfer, Judy Perry, Louisa Rosenheck</i> | |
| 5. Collaborative Design (CODE) as a Teacher Professional Development Model in Francophone and Anglophone Quebec | 1134 |
| <i>Therese Laferriere, Alain Breuleux</i> | |
| 6. Knowledge Building Teacher Network (KBTN) in Hong Kong: Sustaining and Scaling up Knowledge Building through Principle-Based Innovation | 1139 |
| <i>Carol Chan, Nancy Law, Diane Hui, Yuen Han Fung, the KBTN Team</i> | |
| 7. Orchestrating Collaborative Science Curriculum Across Formal and Informal Contexts | 1143 |
| <i>Mike Tissenbaum, Michelle Lui, James D. Slotta</i> | |
| 8. Using Google Sites in collaborative inquiry project-based learning | 1148 |
| <i>Samuel Kai Wah Chu</i> | |
| 9. Dialogical learning supported by Knowledge Practices Environment | 1150 |
| <i>Sami Paavola, Merja Bauters, Christoph Richter, Crina Damsa, Klas Karlgren, Eini Saarivesi, Seppo Toikka, Minna Lakkala, Hanni Muukkonen, Liisa Ilomaki</i> | |
| 10. Creativity of Teachers and Peer-Student-Tutors through Video Media at the Intersection of Content and Cognition | 1154 |
| <i>Eric Hamilton, Nancy Harding, Gina Chaves, Wendy Chaves</i> | |
| 11. ICT for educational pedagogical innovations and learner diversity | 1159 |
| <i>Yiu Yee Ku, Andrew Chung Yee Tse, Keung Kai Chan, Kenneth Cheng, Alison Lau, Tung Keung Poon</i> | |

12. Designing visual tools to scaffold the process of learning how to learn together <i>Reuma De-Groot, Baruch Schwarz, Rupert Wegerif, Yang Yang, Andreas Harrer, Chronis Kynigos, Bruce McLaren, Manolis Mavrikis</i>	1162
13. Teacher as co-designer in developing technology that supports Liberal Studies learning <i>Nancy Law, Yeung Lee, S. M. Kwok, Bonnie Lam, K. C. Ho</i>	1164
14. Accelerating Learning to Write with Reciprocal Peer Review <i>Kwangsue Cho, Jungtaek Im, Namseok Lee, Ho-Chul Shin</i>	1166
15. Automated Data Analysis to Support Teacher's Knowledge Building Practice <i>Leng Jing, Johnny Yuen, Wing Wong, Nancy Law, Yonghe Zhang, Stephane Allaire, Christian Perreault, Therese Laferriere, Christopher Teplovs</i>	1168
16. Design and Technologies for Supporting Collaborative Learning with Multiple Representations <i>Gaelle Molinari, Daniel Bodemer, Manu Kapur, Nikol Rummel, Armin Weinberger</i>	1170
17. Action research on the effectiveness of partnership collaboration in ICT language projects <i>Henry Ha, Jane Yip, Ka Tim Chu, Shirley Lit, Chi Kin Chow</i>	1175
18. Knowledge Building International Project : Designs for Deep Understanding <i>Thérèse Laferrière, Christian Perreault, Pier-Ann Boutin, Nancy Law, Johnny Yuen, Mireia Montané, Oscar Hernandez Lopez, Pere Boluda, Marta Blancafort</i>	1178
19. Supporting innovative teaching and responding to change with an intelligent collaborative design environment <i>Dejan Ljubojevic, Brock Craft, Diana Laurillard</i>	1183
20. School Network for Enhancing Student Information Literacy Across the Curriculum <i>Ching Yin Kwok, Siu Fan Lau, Yin Wai Yvonne Choi, Lok Sze Chan</i>	1185
21. SimScientists: Using Science Simulations to Promote Model-Based Learning and Assessment <i>Edys S. Quellmalz, Barbara Buckley</i>	1188
VOLUME III PART 4: PRE-CONFERENCE EVENTS: TUTORIALS	1192
1. Leveraging tool support for the analysis of computer-mediated activities <i>Gregory DYKE & Carolyn ROSÉ</i>	1193
2. Introduction to Social Network Analysis theory and its application to CSCL <i>Christophe REFFAY & Alejandra MARTÍNEZ-MONÉS</i>	1195
3. Designing Digital Curricula and Visualizations in The New WISE Environment to Facilitate Collaborative Science Learning <i>Hsin-Yi CHANG, Ji SHEN, Keisha VARMA, Jennifer CHIU</i>	1197
VOLUME III PART 5: PRE-CONFERENCE EVENTS: WORKSHOPS	1198
1. How to integrate CSCL in classroom life: Orchestration <i>Miguel NUSSBAUM, Pierre DILLENBOURG, Frank FISCHER, Chee-Kit LOOI, Jeremy ROSCHELLE</i>	1199
2. Connecting Levels of Learning in Networked Communities <i>Daniel SUTHERS, Christopher TEPLOVS, Maarten DE LAAT, Jun OSHIMA, Sam ZEINI</i>	1200

3. Discussing and Synthesizing Three Positions in Computer-supported Inquiry Learning from a Design Perspective: Mobile Collaboratories, Emerging Learning Objects, and Personal Inquiry	1202
<i>Daniel SPIKOL, Marcelo MILRAD, Astrid WICHMANN, Ulrich HOPPE, Jan ENGLER, Ton DE JONG, Roy Pea, Heidy Maldonado, Eileen SCANLON, Canan BLAKE, Claire O'MALLEY, Stamatina ANASTOPOULOU</i>	
4. Robotics for CSCL	1205
<i>Naomi MIYAKE, Hiroshi ISHIGURO, Takayuki KANDA, Hajime SHIROUZU</i>	
VOLUME III PART 6: DOCTORAL CONSORTIUM	1206
CSCL 2011 Doctoral Consortium Workshop	1207
<i>Carol Chan, Christopher Hoadley, Kristine Lund</i>	
1. Cyberscouts: a model for scaling-up afterschool educational gaming	1209
<i>Jacob Dayan, Yael Kali</i>	
2. The psychological reality of virtual environments: Assessing the development of ecological thinking in a virtual environmental education experience	1214
<i>Elizabeth Bagley</i>	
3. Web-based Collaborative Inquiry in Secondary Science Education	1219
<i>Annelies Raes, Tammy Schellens</i>	
4. Can "Prominence" and "Aggression" Enhance Learning?	1224
<i>Anja Rudat</i>	
5. Collaborative Learning with Multiple Representations in a Computer-Based Setting	1229
<i>Katharina Westermann</i>	
6. The diffusion and implementation of learning management systems in higher education	1234
<i>Andrew Krumm</i>	
7. A scheme for analyzing the development of knowledge-building discourse	1239
<i>Ella L. F. Fu</i>	
8. Supporting getting structural elements for Constructive Interaction	1244
<i>Sayaka Tohyama</i>	
9. Activity-based tools to support orchestration of blended CSCL scenarios	1249
<i>Luis P. Prieto</i>	
10. Social Network Analysis of Collaborative Knowledge Creation in Wikipedia	1254
<i>Jassen Halatchliyski</i>	
11. Collaborative Knowledge Exchange using Patterns	1259
<i>Franziska Arnold</i>	
12. The Nature of Knowledge Co-construction: Reconsidering Meaning-making of Postings in Online Group Discussion	1264
<i>Hsiu-Mei Chang</i>	
13. Fostering Computer-Supported Knowledge Building through Formative Assessment among Chinese Tertiary Students	1269
<i>Chunlin LEI</i>	
14. Trust Modeling and Evaluation in Personal Learning Environments	1273
<i>Na Li</i>	
15. Supporting Progressive Idealization of Physics Understanding through a Mixed Reality Learning Environment	1278
<i>Garrett Smith</i>	

16. Study of the role of graphic representations and their inter-relation with written language in collaborative problem solving <i>Mayra Fabiana Angeles Sánchez</i>	1283
VOLUME III PART 7: EARLY CAREER WORKSHOPS	1288
The ISLS Early Career Workshop <i>Cindy Hmelo-Silver, Frank Fischer, Tak Wai Chan</i>	1289
VOLUME III PART 8: POST-CONFERENCE EVENTS	1290
CSCL 2011 Post-conference Events in Mainland China <i>Ronghuai Huang, Shengquan Yu, Zhiting Zhu, Youqun Ren, Fuyin Xu, Hongguang Peng, Baohui Zhang, Siu Cheung Kong, Nancy Law</i>	1291
1. ICT in EFL Teaching and Teacher Development: Responding to a National Reform <i>Zhiwen Hu</i>	1294
2. Exploring Ways of Engaging Pre-Service Teachers in Online Collaborative Knowledge Construction <i>Fei Gao</i>	1296
3. 概念转变视角下的教科书研究 <i>宗华</i>	1298
4. 学科知识对化学教师设计教学的影响 — 在系统观视角下的研究 <i>沈睿</i>	1300
5. 使用“通过设计学习”的方法促进职前教师 TPACK 水平的提高 <i>詹艺, 程佳铭, 俞琼, 任友群</i>	1302
6. 科学争议性话题教学对学生反思判断能力的影响 <i>俞琼, 裴新宁, 詹艺</i>	1304
7. Giving parents feedback on individual children's progress during on-line educational games : www.kizz.tv <i>Kristine Lund, Vincent Tauzia, Stéphane Reynaud, Margaret Edwards</i>	1306
8. The Inspiration of the Studies of Learning Science in the West for the Studies of Educational Technology in China <i>Haiyan Wang, Jim Slotta, Naxin Zhao, Mike Tissenbaum, Stian Håklev</i>	1308
9. How the Creation of Open Educational Resources Can Impact the Creators: Improving the Quality of Undergraduate Teaching in China <i>Stian Håklev</i>	1310
10. ICT and Educational Transformation: Factors Towards a Complex Systems Approach to Personalized Learning Communities <i>Eric Hamilton</i>	1312
AUTHOR INDEX	xxxi-xxxvi

(END OF VOLUME III)

Volume II



Short papers & posters

Divergent and Convergent Knowledge Processes on Wikipedia

Iassen Halatchliyski, Joachim Kimmerle, Ulrike Cress, Knowledge Media Research Center & University of Tuebingen, Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany
 Email: i.halatchliyski@iwm-kmrc.de, j.kimmerle@iwm-kmrc.de, u.cress@iwm-kmrc.de

Abstract: The paper presents a new theoretical consideration of knowledge processes bridging the individual and the collective level. Building on a differentiation between accommodation and assimilation of knowledge in wikis, we derive divergence and convergence from intelligence and creativity research and reconstruct their impact on the open-ended development of knowledge. The distinction from related CSCL constructs is elaborated. Using examples from Wikipedia, the definition of divergence and convergence is illustrated in the dynamic context of article development.

Introduction

Research on CSCL is marked by different emphasis of individual and collective knowledge presenting a challenge of integrating the theoretical concepts. Sfard (1998) has proposed a well-known differentiation between two basic approaches, the knowledge acquisition metaphor and the participation metaphor. The former metaphor refers to models that may acknowledge social factors in the learning process, but focus on how individuals develop certain cognitive structures and acquire understanding. The latter metaphor concerns models of knowledge as a collective phenomenon that emerges from people's activities, situated in a socio-cultural context, and cannot be reduced to single contributions (Stahl, 2006).

Paavola, Lipponen and Hakkarainen (2004) have introduced a third metaphor that goes beyond Sfard's dichotomy in order to describe models of long-term *knowledge creation*. The theory of *knowledge building* (Scardamalia & Bereiter, 2006) belongs to this perspective and illustrates how communities can create knowledge collaboratively by an ongoing incremental advancement of shared dynamic artifacts. Artifacts such as explicit ideas at the same time mediate and coordinate the interaction between collaborators. The exact knowledge processes between individuals and mediating collaborative artifacts are addressed by the *co-evolution model* (Cress & Kimmerle, 2008) transferring some of Piaget's (1983) ideas to the context of social software and wikis in particular. Knowledge incongruities between the mediating artifact system of a wiki and the cognitive systems of its users are suggested to create a cognitive conflict that is resolved through the processes of assimilation and accommodation. Assimilation means that new information is received and customized to fit the prior knowledge. Accommodation, accordingly, means that new information leads to structural changes of the prior knowledge. The predicted outcome of the model is individual learning – internalization – or a change of the information in the wiki – externalization.

“Knowledge creation” models deal, compared to the other two metaphors, in the most explicit way with the interaction between individual and collective knowledge. They are best suited to give a more accurate account of how collective knowledge emerges from the collaboration of a large number of individuals. This form of collaboration has become more common as a result of the emergence of Web 2.0 technologies, with Wikipedia being the most remarkable example (Halatchliyski, Moskaliuk, Kimmerle, & Cress, 2010). We consider the postulated equivalence of assimilation and accommodation processes at individual and collective level as a very interesting research question for CSCL. In this paper, we will elaborate on the equivalence, introducing the processes of divergence and convergence as complementary to the assimilation-accommodation perspective. We will explain the origins of the concepts and differentiate our understanding against other usages of these terms in the field of learning sciences. For the sake of concreteness, we will provide some illustrative examples from Wikipedia, the Online Encyclopedia.

Knowledge Processes of Convergence and Divergence

Regarding the perspective of an *individual*, the convergence and divergence opposites were first described by Guilford (1950). He later included them as dimensions of thinking into his model of intelligence (Guilford, 1967) contrasting the identification of a single correct solution to a problem with the generation of many different possible alternatives. At about the same time, Hudson (1966) described the opposites as different cognitive styles, correlating with the different abilities of students in science and arts. This started a controversy about the connection of both styles with intelligence and creativity. Convergents were described as people who tend to analyze systematically, evaluate critically and deduce logically one feasible solution. Divergers were supposed to be intuitive explorers of ideas in multiple frames. Later it was concluded that these styles were not a stable personal characteristic and better seen as modes of thinking (Robertson, 1985). Creativity researchers also acknowledged the need to achieve a balance between both complementary modes in order to obtain relevant and, at the same time, original solutions or products (Levine & Moreland, 2004).

Convergence and divergence have also been discussed in the context of *group* creativity and decision making. Brainstorming and other creativity techniques are widely applied and aim at facilitating divergent thinking and development of innovative ideas. Otherwise, the full solution to a problem often demands the choice and implementation of a single best idea. Janis (1982) has shown that this process of convergence in groups may be very erroneous, coining the term groupthink.

Creative processes in groups have a long tradition of being divided into divergent and convergent *phases* (Finke, 1992). In the context of CSCL, Onrubia and Engel (2009) noted that many researchers have also defined various numbers of stages of the joint creation of knowledge. Convergence is supposed to occur at a later moment after people have shared knowledge, identified differences and negotiated common understanding. Fischer and Mandl (2005) found that convergence is beneficial to learning. Other researchers have proposed the implementation of *scripts* that guide the process by dictating a sequence of joint activities (Dillenbourg, 2002). The reason why more attention is paid to convergence than divergence is the view that constructing shared understanding is the main goal of collaborative learning (cf. Roschelle, 1992). A knowledge building discourse is not an argumentative debate, where people try to defend different opinions, but it aims at collaboratively advancing ideas and reaching commonly accepted solutions to problems (Scardamalia & Bereiter, 2006).

The above results apply best in those settings in which small groups of people collaborate on solving a restricted problem with constraints on time, goals, or solution approaches. Observations in different settings (cf. Liu & Wang, 2010) show that convergence and divergence can repeatedly occur and complement each other during different stages of group interaction. Jorczak (in press) also challenged the idea that convergence alone is beneficial for learning. He emphasized the need for cognitive conflict within and among group members based on divergence, so that improved learning and knowledge can be achieved upon conflict resolution. Another recent analysis of knowledge building in school classes (Zhang & Messina, 2010) confirms the equivalent importance of both the accumulation of variable ideas as well as their critical examination.

In the present work, we deal with a mass collaboration setting, as in the case of the open-ended project Wikipedia. We apply these concepts to a dynamic knowledge artifact, a wiki, where diverging understanding can also be expected at later stages of collaborative knowledge creation. The co-evolution model (Cress & Kimmerle, 2008) offers a good theoretical starting point, as it is geared to the learning context of wikis. It describes assimilation and accommodation as two processes of adaptation of an individual or a wiki, following the experience of a cognitive conflict. Referring to wikis, assimilation is defined as the addition of information at a suitable place, without establishing new connections that would change the structure of the wiki. Accommodation means a distinct change of the knowledge organization through rearrangement of paragraphs and pages, which results in a new focus. Both processes are compatible, often appear together and concern the question of structural changes in the wiki (Moskaliuk, Kimmerle, & Cress, 2009).

Divergence and convergence, the processes in the focus of the current discussion, are not derived from Piaget's theory, and represent a different categorization of knowledge creation. So the essence of divergence and convergence shows itself not in the way *how* new information is integrated – as in the case of assimilation and accommodation –, but in the *qualities* of this new information, compared to the available knowledge. So we see these two categorizations of processes as independent from each other.

We define the characteristics of the new processes in a wiki on the lines of the definition of divergent and convergent thinking at an individual level. Divergence is present when a new idea is added that opens a new direction for addressing the problem of a specific article page. This may be new information that cannot be categorized under the available viewpoints, an alternative explanation, or it may be a new way of describing the issue. Convergence refers to acts based on critical evaluation and logical reasoning. Here, the result is not so much the addition of new aspects as the establishment of a coherent structure of the presentation. This may be done by subsuming some of the new or already available major points under a common category, through abstracting a model or principle, or through eliminating a conflicting issue. Some actions, like corrections of simple mistakes, may not be categorized in this schema, and some other actions may contain elements of both processes. The categorization may also be applied to analyses with different granularity, for example, at the level of an article, at the level of a connected group of articles like a wiki category, or at the level of a whole knowledge domain like a network of categories and articles. Complex actions may be both converging and diverging at different levels at the same time. For example, the movement of a section from an existing article into a new article would represent a convergence for the old article and a divergence for the set of articles that both the old and the new article belong to.

This new categorization schema is not a substitute for the accommodation-assimilation perspective. A single change may, for example, be a case of accommodative restructuring that resolves a conflict in a wiki, and at the same time it may be classified as divergence or convergence or neither of these. Using dynamic social network analysis, Kimmerle, Moskaliuk, Harrer und Cress (2010) have given an example of high level processes concerning a set of articles about schizophrenia. The researchers identified accommodative reorganization of clusters of article on different explanatory approaches to the mental disorder. Articles on two

of the approaches merged into one tightly interconnected cluster – in our view another example of a higher-order convergence process.

As with the assimilation-accommodation dichotomy, we describe here two complementary processes regulating the development of both individual and collective knowledge. In the following section we will provide an illustration of the differentiation between assimilation, accommodation, divergence and convergence, using the edit history of the English Wikipedia article on *Knowledge* (1).

Wikipedia Examples

The following examples are reported chronologically and reflect the starting period of the article *Knowledge*. Each case is chosen to show one of the eight possible occurrences of the independent categories, assimilation, accommodation, divergence, convergence, and their combinations.

The article was started on 20th August 2001 as a lecture on philosophy of nearly 4000 words. Its main point was that “Knowledge is justified, true belief.” In the first example a short general definition was added at the head of the long lecture on the 30th of July 2002:

Knowledge is those descriptions, assertions, concepts, formulations and procedures which to a reasonable degree of certainty are either true or useful.

This change could be interpreted as divergence, because *usefulness* was a new idea introduced in the article. At the same time, it is not assimilation, as the change does not follow the previous pattern of exposition. It could also not be seen as accommodation, because the definition appears detached from the long lecture and does not meaningfully change the overall structure of the article and the overall concept of *knowledge*.

In our second example, the definition was extended on 5th and 15th September 2002 to differentiate a *factual* and an *inferential* type of knowledge, as well as the knowledge sources *authority*, *reasoning* and *experience*:

Knowledge may be factual or inferential. Factual knowledge is based on direct observation. It is still not free of uncertainty... Inferential knowledge is based on reasoning from facts or from other inferential knowledge such as a theory. It may or may not be possible to verify by observation or testing. (sic)

“... three ways in which men think that they acquire knowledge of things - authority, reasoning, and experience ...”

The new changes resemble the previous example and could be interpreted as divergence. After the addition of the new paragraphs, the lecture was not displaying the only perspective on *knowledge* any more. Although the connection between both paragraphs is not quite obvious, and a common new direction for the article is difficult to be determined, accommodation has seemingly started to take place. Compared to the previous example, the topic of the article was receiving a different shape and meaning.

The third example displays a new paragraph from 19th September 2002 that provided a new organization for the ideas from the last example:

Knowledge consists of beliefs about reality. One way of deriving and verifying knowledge is from tradition or from generally recognized authorities of the past, such as Aristotle. Knowledge may also be based upon the pronouncements of secular or religious authority] such as the state or the church. A second way to derive knowledge is by observation and experiment, the scientific method. Knowledge may also be derived by reason from either traditional, authoritative, or scientific sources and may or may not be verified by resort to observation and testing. (sic)

We chose this as an example of convergence, because it presents a new systematics that encompassed already available ideas from different paragraphs, and consolidated them into a single picture. The concept of *belief* was mentioned and connected the whole introductory part to the lecture part. The processes of *deriving* and *verifying* knowledge were stated, and an overview of different ways was provided. Accommodation was also present at this moment, because the article obviously had a new structure – a beginning with definitions and classifications, and a longer easy-to-read discussion.

Our fourth example refers to relativizing statements that were added on 18th April 2003:

What constitutes knowledge, as well as truth and utility, is often contentious and debated by philisophers, social scientists, and historians. (sic)

We tend to interpret this as a pure accommodation, because, here, the concept of *knowledge* is placed into a new and broader context. The change is based not on new alternative ideas (no divergence) and not on

new conclusions from available knowledge (no convergence). The same is true of the revision on 20th April 2003, when the sentence “*Knowledge is...*” was changed into “*Knowledge includes, but is not limited to...*”.

The fifth example shows how some essential ideas from the lecture were paraphrased on 9th May 2003. The main points were abstracted from many examples brought up to facilitate the lecture. The lecture part itself could then be safely deleted on 18th May 2003.

Conventionally, knowledge is defined as a justified, true belief. “Justified” means that one has some evidence supporting the belief. “True” conventionally means something like this: one could make plans based on a true belief, and they would not fail.

Every part of this definition can be, and has been attacked. There are problems with the objectivity, adequacy and limits to justification. There are problems with various definitions of truth... (sic)

Although the structure of the whole article changed, this transformation is not a case of assimilation or accommodation as no new information was added to the article. This is a simple form of convergence.

The sixth example deals with changes stressing the *scientific method* on 25th May 2003:

The only way to gain reliable knowledge about the physical world that we live in is through the scientific method. ... A scientist picks one question of interest, and based on all previous information and experience, develops a hypothesis... (sic)

Here, as we see it, joint convergence and assimilation took place. The contributor singled out *scientific method* as the main way of deriving and verifying reliable knowledge, compared to following authorities or logic (convergence of alternatives). At the same time, a description of details of the scientific process was added, which did not change the notion of knowledge (assimilation of new information). So, without changing the structure of the whole exposition, the new revision placed one available aspect more into focus.

The seventh revision example concerns a short reference added on 5th June 2003:

What constitutes knowledge, certainty, truth and utility, are deeply contentious and debated by philosophers... As just one example, Ludwig Wittgenstein wrote “On Certainty” ... exploring relationships between knowledge and certainty.

The change represents a case of assimilation alone, because it only added information that fitted the available exposition. It did not introduce new alternative concepts (no divergence), did not establish new connections (no convergence), and did not change the structure of the knowledge article (no accommodation).

The last example here shows a sentence from the same revision on 5th June 2003 that added a new perspective on *beliefs* and their potential for action (the part outside of the brackets):

[Most people can produce descriptions of beliefs, at least when they're asked a relevant question.] but perhaps not state their limits so clearly as to know reliably when that belief is actionable and when not.

The change tends to express simultaneous divergence and assimilation. While the sentence was meant to describe an alternative idea, this divergent idea was assimilated and did not have an impact on the overall concept of *knowledge*.

These eight cases consider knowledge processes at the scale of a single article. As previously mentioned, the processes of interest can be identified also from the broader perspective of sets of articles. For instance, the same article *Knowledge* was split into two articles, *Knowledge (philosophy)* and *Propositional knowledge*, on 10th June 2003. On 14th April 2004 *Knowledge (philosophy)* was re-incorporated into the new *Knowledge* article. Such movements of paragraphs or whole articles can be studied as processes of divergence and convergence, in order to identify evolution patterns of a broader topic and also the co-evolution with different groups of contributing authors.

Conclusion

The Wikipedia examples were chosen to characterize the nature of both processes of convergence and divergence in collective knowledge, and to differentiate them from the processes of accommodation and assimilation, as postulated by the co-evolution model. It is obvious that this identification is susceptible to interpretations. Compared to the relatively simple examples here, there may be complicated cases where divergence and convergence may occur simultaneously. Nevertheless, we believe that the new categorization bears a potential for grasping analyzing detailed mechanisms of mass collaboration, as in the case of Wikipedia.

The examples showed that convergence and divergence processes alternate with each other in the course of article development. It is possible to classify very detailed changes at the level of a single article and also at the level of groups of articles, so a coarse-grained study is also feasible. As a future direction for

research, we would like to show how detailed studies of these processes can help answering particular questions concerning the development of single articles or whole knowledge domains of connected articles.

Endnotes

- (1) The article history until the 10th of June 2003 is accessible at: [http://en.wikipedia.org/w/index.php?title=Descriptive_knowledge&action=history&year=2003&month=6]. It has remained with an older version of the article that was later renamed to Descriptive knowledge.

References

- Cress, U., & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 105-122.
- Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed), *Three worlds of CSCL. Can we support CSCL* (p. 61-91). Heerlen: Open Universiteit Nederland.
- Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative Cognition: Theory, Research and Application*. Bradford: The MIT Press.
- Fischer, F., & Mandl, H. (2005). Knowledge convergence in computer-supported collaborative learning: The role of external representation tools. *Journal of the Learning Sciences*, 14(3), 405-441.
- Guilford, J. P. (1950). Creativity, *American Psychologist* 5(9), pp. 444-454.
- Guilford, J. P. (1967). *The Nature of Human Intelligence*. New York: McGraw-Hill.
- Halatchliyski, I., Moskaliuk, J., Kimmerle, J., & Cress, U. (2010). Who integrates the networks of knowledge in Wikipedia? *Proceedings of the 6th International Symposium on Wikis and Open Collaboration*. (No. 1) New York: ACM Press.
- Hudson, L. (1967). *Contrary Imaginations; a psychological study of the English Schoolboy*. Harmondsworth: Penguin.
- Janis, I. L. (1982). *Groupthink: Psychological Studies of Policy Decisions and Fiascoes*. New York: Houghton Mifflin.
- Jorczak, R. L. (in press). An information processing perspective on divergence and convergence in collaborative learning. *International Journal of Computer-Supported Collaborative Learning*.
- Kimmerle, J., Moskaliuk, J., Harrer, A., & Cress, U. (2010). Visualizing co-evolution of individual and collective knowledge. *Information, Communication and Society*. 13(8): 1099 - 1121.
- Levine, J. M., & Moreland, R. L. (2004). Collaboration: The social context of theory development. *Personality and Social Psychology Review*, 8(2), 164-172.
- Liu, M.-C., & Wang, J.-Y. (2010). Investigating Knowledge Integration in Web-based Thematic Learning Using Concept Mapping Assessment. *Educational Technology & Society*, 13(2), 25-39.
- Moskaliuk, J., Kimmerle, J., & Cress U. (2009). Wiki-supported learning and knowledge building: Effects of incongruity between knowledge and information. *Journal of Computer Assisted Learning*, 25(6), 549-561.
- Onrubia, J., & Engel, A. (2009). Strategies for collaborative writing and phases of knowledge construction in CSCL environments. *Computers & Education*, 53(4), 1256-1265.
- Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of Innovative Knowledge Communities and Three Metaphors of Learning. *Review of Educational Research*, 74(4), 557-576.
- Piaget, J. (1983). Piaget's theory. In P. Mussen (ed.). *Handbook of Child Psychology*. 4th edition. Vol. 1. New York: Wiley.
- Robertson, I. T. (1985). Human information-processing strategies and style. *Behaviour and Information Technology* 4(1), 19-29.
- Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *The journal of the learning sciences*, 2(3), 235-276.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Eds.), *Cambridge handbook of the learning sciences* (pp. 97-118). New York: Cambridge University Press.
- Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, 27(2), 4-13.
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
- Zhang, J., & Messina, R. (2010). Collaborative productivity as self-sustaining processes in a Grade 4 knowledge building community. In K. Gomez, L. Lyons, & J. Radinsky (Eds.), *Learning in the Disciplines: Proceedings of the 9th International Conference of the Learning Sciences - Volume 1* (pp. 49-56). Chicago, IL: International Society of the Learning Sciences.

Evaluation by Grade 5 and 6 Students of the Promisingness of Ideas in Knowledge-Building Discourse

Bodong Chen, Maria Chuy, Monica Resendes, Marlene Scardamalia, Carl Bereiter, University of Toronto,
252 Bloor Street West, IKIT 9th floor, Toronto, ON, M5S 1V6, Canada

Email: bodong.chen@utoronto.ca, maria.chuy@utoronto.ca, monica.resendes@utoronto.ca,
marlene.scardamalia@utoronto.ca, carl.bereiter@utoronto.ca

Abstract: Knowledge creation requires identifying and pursuing promising ideas—ideas that in their nascent form may not seem like much but that with development could grow into something big. The goal of our research is to develop a tool to explore the concept of promisingness and “big ideas,” especially elementary school students’ ability to make “promisingness judgments” regarding ideas in peer discourse. Toward this end we developed a “Big Ideas” tool to facilitate students’ selection of the ideas they thought were promising in their online discourse. A study conducted in two Grade 5/6 classes examined the nature of “big ideas” selected from the online discourse of younger Grade 4 students. A preliminary analysis indicated that students tended to identify as promising important facts and questions in the Grade 4 discourse. This study will inform future work in designing tools, language, and techniques to facilitate the concept of promisingness.

Introduction

This paper describes a preliminary study aimed at investigating elementary students’ ability to evaluate the “promisingness” of ideas in student-generated “knowledge-building discourse.” The study is part of a broader research effort aimed at pursuing designs and techniques to support idea-centered, knowledge-creating dialogue including an empirically grounded taxonomy of students’ ways of contributing to knowledge-building discourse.

The dynamics of knowledge creation and pursuit of “new ideas” serve as a focal point for three influential “models of innovative knowledge communities” identified by Paavola et al. (2004). They include Nonaka and Takeuchi’s (1995) model of knowledge-creation, Engeström’s (1999) model of expansive learning, and Scardamalia and Bereiter’s (2003) theory of Knowledge Building. Among these three models, Knowledge Building theory is the one most applicable to educational contexts. Foundational to Knowledge Building theory is the notion that ideas ought to be at the centre of educational endeavors and continually improved through a social process, with a shared goal of advancing the frontiers of knowledge, as members of the community perceive those frontiers (Scardamalia & Bereiter, 2003). Knowledge creation is a risky business, requiring community members evaluate the *promisingness* of ideas to determine if those ideas are worth laboring to improve (Bereiter & Scardamalia, 1993; Bereiter, 2002).

The view of ideas as real things that can be treated as objects of inquiry and improved has informed the design of Knowledge Forum software that supports knowledge building pedagogy and the process of knowledge creation (Scardamalia, 2004). Current features in Knowledge Forum, such as theory-building scaffolds and rise-above notes and views, have produced strong educational results and allowed us to identify levels of competence that young students are capable of but are obscured by traditional learning environments and not revealed by current assessments (Scardamalia & Bereiter, 1991; Scardamalia, 2003; Sun, Zhang & Scardamalia, 2008). The current design does not explicitly support students’ evaluation of the promisingness of ideas. As a result, students may become lost in unpromising ideas, with promising ideas lost due to information glut. Is there a way to facilitate the process of identification and evaluation of promising ideas within complex knowledge spaces? How can we help students move from the first-level processes of reading and posting ideas in Knowledge Forum to higher-level ones such as creating rise-above contributions? What design improvements can help students develop better and bigger ideas in their community space? Answering these questions calls for a deeper understanding about what students perceive as promising in knowledge-building discourse.

This paper describes a preliminary study aimed at uncovering elementary students’ ability to evaluate the promisingness of ideas in their community. In this study, we are going to examine the nature of the ideas that have been identified by students as being “promising.” Previous research lists a number of taxonomies through which these aspects can be analyzed. For instance, Leng, Lai, and Law (2008) studied levels of cognitive complexity in knowledge-building discourse, by categorizing notes into four categories: *argument* (a claim with one or more reasons), *statement* (a claim without reason), *information*, and *question*. Based on the procedures of Grounded Theory, Chuy and colleagues (2010) came up with a finer grained list of ways of contributing to knowledge-building discourse, including *formulating thought-provoking questions*, *theorizing*, *designing an experiment*, *working with evidence*, *creating syntheses and analogies*, and *supporting discussion* as the main categories. Since structural complexity is treated as an important criterion in evaluating students’ ideas,

we apply Biggs and Collis' (1979, 1982) structure of the observed learning outcome (SOLO) taxonomy as a measure of structural complexity and as a correlative of the "bigness" of students' ideas.

Methods

Participants

Participants in this study were students and teachers from two Grade 5/6 classes at an elementary school located in downtown Toronto. Each class included one teacher and around 20 students (with almost equal numbers of boys and girls). In this elementary school, knowledge-building discourse is integral to regular classroom activities, and both classes we studied had been committed to knowledge building pedagogy and had been using Knowledge Forum for several years.

Big Ideas Tool

By integrating various functions such as highlighting, tagging, and visualization, the Big Ideas tool enables students to collaboratively evaluate the community's ideas. As they read these ideas they can tag ones they find promising, using a categorization scheme of their choice (promising idea, big idea, misconception, etc.). They can then view the subset of selected ideas in their public space, and if they wish, export that subset to a new view for further inquiry. The user interface for identifying ideas in the study reported in shown in Figure 1. When reading a note, a student may highlight a portion of the text by clicking on the "Ideas" button. In the activated pop-up menu, the student can choose a color, corresponding to the categorization scheme defined by community members. For example, Green might be defined as "big idea," Blue as "promising theory." After the idea is identified with the "color wand," its text is highlighted with that color in the note content editor pane. The highlighted text will also show in the idea text pane below. The default option is that students do not see each other's highlighted ideas, so as not to interfere with reading. However, the "Show All Ideas" checkbox will allow a student to display all ideas color-coded. The "Hide Colors" option enables students to hide or show colors in the note editing area.

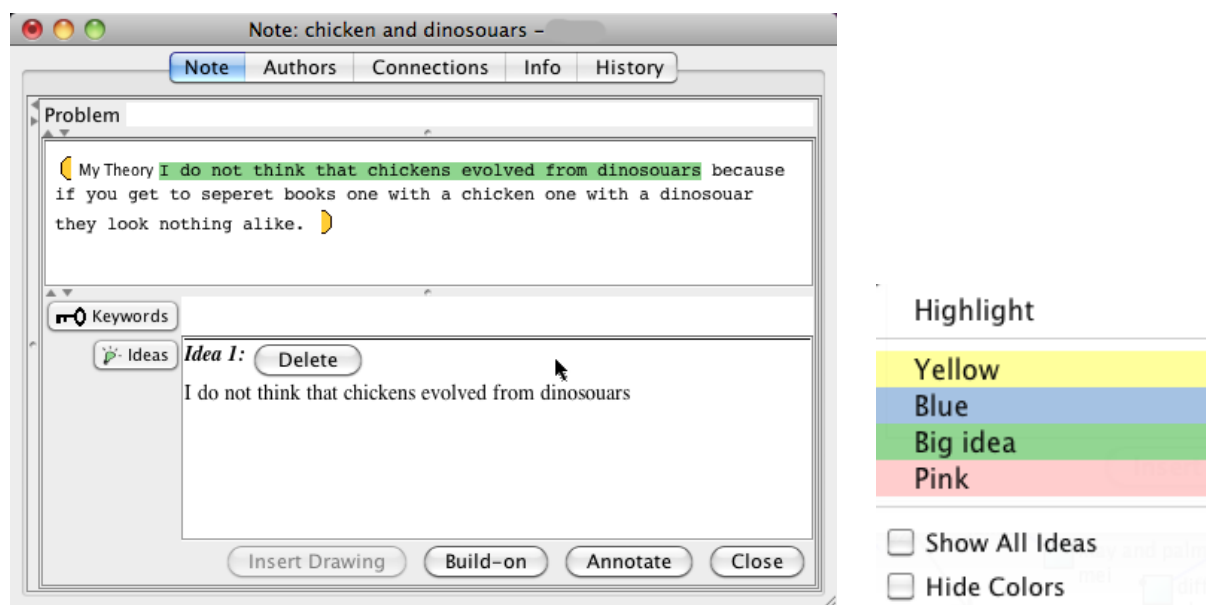


Figure 1. Note Editing Window with an Idea Highlighted; the Pop-up Menu Shows Color Coding Options.

When students collaboratively identify promising ideas in their Knowledge Forum database, the ideas they highlight might have partial overlap. Eventually, their collective efforts will lead to the list of promising ideas spanning overlapping sets. A menu button allows them to display ideas of any color categorization in descending order according to the times the idea was identified (the number is displayed to the left of each list entry, see Figure 2). Students can easily toggle back to the full note and context for an idea through a link backwards to the *note* in which an idea "lives." Since the goal of promisingness judgements is to move knowledge-building discourse forward, students and teachers can choose ideas from the list and export them to a new view for further dialogue.

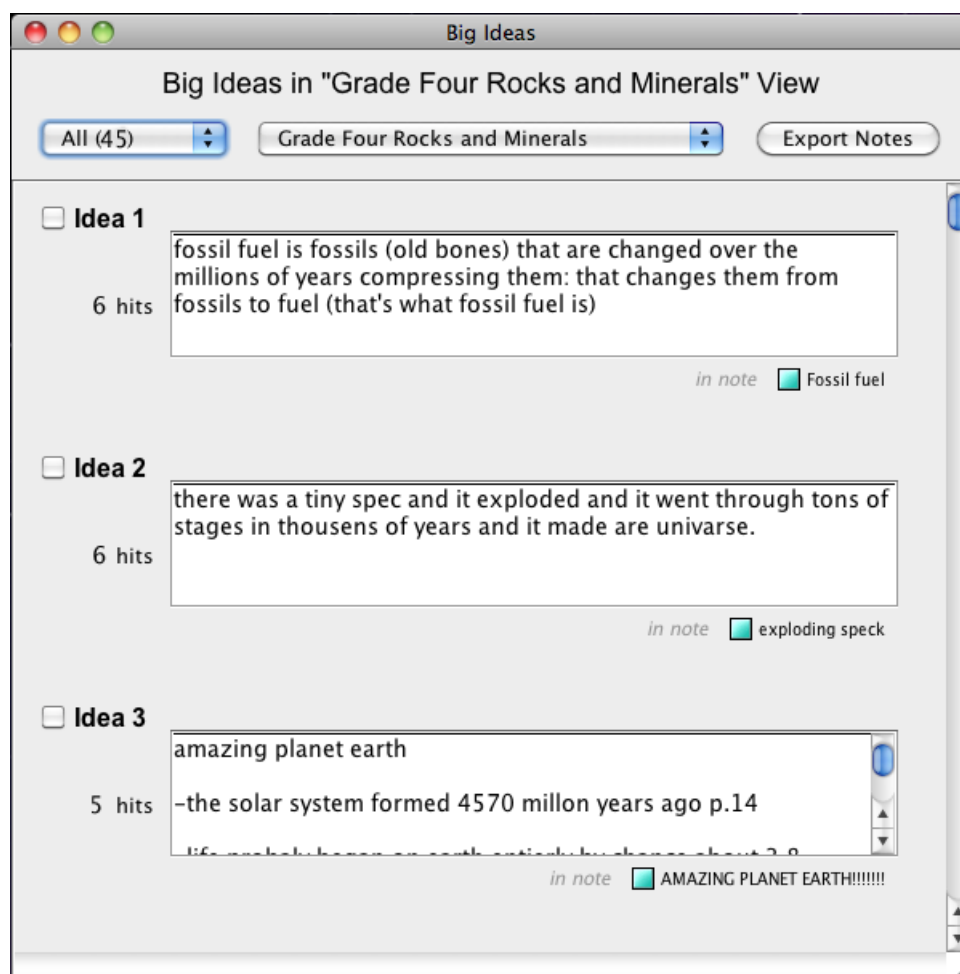


Figure 2. Big Ideas Window That Lists All Selected Ideas from a View.

Procedure

A pilot study was conducted using this tool in two Grade 5/6 classrooms. Three sessions were conducted, lasting a total of 45 minutes and comprising (a) introduction of the Big Ideas tool to students and teachers; (b) students reading notes about “Rocks and Minerals” generated by Grade 4 and identifying promising ideas by means of the “Big Ideas Tool”; and (c) students and teachers providing researchers with feedback regarding the experience and tool.

In the two classes combined, students identified 83 “promising ideas” from 207 notes. Among those ideas, 21 ideas were highlighted at least twice, so there were 45 distinctive ideas. The “hits” of the final idea list ranged from 1 to 6 ($M = 1.91$, $SD = 1.33$).

Data Analysis

To determine if selected ideas fell within specific “idea types,” student selections were divided into three categories (see Chuy et al., 2010 for details): (1) *Theory*—a thought proposed by a student usually with an explanation, (2) *Fact/Evidence*—a well-accepted fact or a piece of information from authoritative sources provided by a student, and (3) *Question*—an expression in an interrogative form.

Because the structural complexity of ideas is often evaluated in school learning, students might think that “big ideas” are more structurally complex ideas. To check this possibility we used Biggs and Collis’ (1979, 1982) structure of the observed learning outcome (SOLO) taxonomy to evaluate student selections. The SOLO taxonomy contains five levels of complexity:

1. *Pre-structural*: bits of disconnected information.
2. *Uni-structural*: simple and obvious, but unelaborated connections
3. *Multi-structural*: connections between ideas, but no meta-connections or elaborated significance.
4. *Relational*: information meaningfully related to the whole.
5. *Extended abstract*: connections not only within the given subject area, but also beyond it; generalize and transfer principles.

Two independent raters used the two coding systems to code the identified “big ideas.” They agreed in 71% of the coding, and arrived at a final agreement on the remaining 29% through further negotiation.

Results and Discussion

What Do Students Perceive as Promising Ideas?

Using the Big Idea Tool, students identified 83 promising ideas in total: 63.9% of them were “theories” ($n = 53$), 22.9% of them were “fact or evidence” ($n = 19$), and the rest 13.2% were questions ($n = 11$). Thus, while most of the promising ideas identified by students were of a “theoretical nature”, they also included a number of facts, evidence, and questions. This finding is in line with results reported by Chuy, et al. (2010), showing that *working with evidence* and *formulating questions* are two frequent contribution types in students’ discourse. Facts and questions play an important role in moving discourse forward, with questions serving to define or analyze the frontiers of the community knowledge. It seems students are selecting questions of curricular importance: “What is a rock?”, “What is universe?”, “Why rocks are colored?”, and “Is that the diamonds are very small bits of lava when gets cold?” Detailed analysis of discourse contexts and related discussion threads in Knowledge Forum showed that these questions spurred a variety of discourse moves or other ways of contributing to the discourse. Some of them included: *proposing an explanation* (e.g. “a rock is something that got hardened over time. It could be a sand stone, a lava rock and many different kinds of rocks.”), *creating analogies* (e.g. “it [the universe] is a place that planets live, a place like home”), *looking for evidence* (e.g. “good question. I am not sure but the answer may be in a book in the classroom...”), and *contradicting a theory* (e.g. “I do not think that chickens evolved from dinosaurs because... they look nothing alike”). Student choices seem to reflect what they believe is important to their school work.

As for facts and evidences, the following examples represent the ones that helped moving the dialogue forward. “How old is the universe” and “how many layers does a rock could have” were two questions many students kept making guesses about. Students put forward their theories and argued against each other’s theories for many times until two students provided the following authoritative evidence to settle these two problems: “The universe is 13,000,000,000 years old! and the earth is 4,000,000,000 years old!” and “There could probably be tons of layers in rocks like the grand canyon could have 912,456 layers of rock.”

Besides these examples, however, there were also facts and questions that were highlighted not because they were important, but because they had some distinctive “attractiveness.” For instance, there was a note containing nine facts about the earth that included page numbers as references, however the points listed lacked specific context. Thus, such a note could appear to be attractive because of its detailed information, but it may not necessarily be promising for a knowledge-building dialogue.

An interesting phenomenon we noted but could not quantify was that there was little relationship between the promisingness judgments made by the Grade 5/6 students and the amount of emphasis or attention given to these in the original Grade 4 database. Although competing explanations could be proposed to explain these mismatches (e.g., personal or grade-level difference in perceiving promisingness), they seem to highlight the importance of making promising evaluations so as to bring such results forward to the community.

Are Student Judgments of Promisingness Based on Structural Complexity of Ideas?

To answer this question, the SOLO taxonomy was applied to evaluate the structural complexity of “promising” ideas. Results showed all 19 *facts* and 11 *questions* resided on the *pre-structural* and *uni-structural* levels, i.e. they were mostly facts or question with no or only simple and obvious connection. One possible explanation would be that the Grade 4 students’ ideas, which were examined by Grade 5/6 students, did not involve much evidence or explanatory content or design ideas. That is, the students were inclined to ask factual questions or introduce evidence with little obvious connection to the problem. As for 53 theories identified as promising, the following distribution of complexity levels was observed: *pre-structural* ($n = 8$), *uni-structural* ($n = 16$), *multi-structural* ($n = 16$), and *relational* ($n = 13$) levels. There was no theory that reached the level of *extended abstract*. In order to examine whether students tend to highlight theories with higher structural complexity, a one-sample chi-square test was conducted. The results of the test were nonsignificant, $\chi^2(3, N = 53) = 3.226, p > .05$, which implies the distribution of SOLO levels was not significantly different from a chance distribution.

Overall, structural complexity did not seem to be the basis for selecting “big” or promising ideas, but this might simply reflect low complexity of ideas developed in Grade 4 classrooms.

Conclusion and Future Directions

Understanding the promisingness of ideas is a significant challenge in knowledge creation, and is also an important component in moving a knowledge-building discourse forward (Bereiter & Scardamalia, 1993). The goal of this study was to investigate elementary students’ ability to make promisingness evaluations in knowledge-building discourse, to test a new tool to explore promisingness judgments, and ultimately to improve students’ competencies in making promisingness judgments. Towards this end we developed a Big Ideas tool to

enable students to collectively identify promising ideas in Knowledge Forum. A pilot study was conducted with two Grade 5/6 classes. Overall, we were not able to detect promisingness judgments that reflected student selections of interesting ideas that had potential for growth. Instead, students selected as important facts and questions of the sort they address in their school work. Analysis of structural complexity additionally showed that promisingness judgments did not relate to complexity of ideas.

This study represents a first step in exploring students' ability to do promisingness evaluations. Results indicated that students were not working with a concept of promisingness in the intended sense—as an idea with a promising growth trajectory. Substantial additional research is needed to understand the language and tools needed to facilitate judgments of promisingness. To further improve the Big Ideas tool and to find ways to engage students in promisingness judgments, we plan to conduct targeted interventions with this tool in various student populations and use experienced adult raters to more directly assess the promising ideas and seed databases with such ideas. We also plan to extend current functions of the tool by incorporating more sophisticated techniques, including data visualization, social network analysis, and semantic analysis, to better support students' collective work with ideas.

References

- Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. La Salle, IL: Open Court.
- Biggs, J. (1979). Individual differences in study processes and the Quality of Learning Outcomes. *Higher Education*, 8(4), 381-394.
- Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: the SOLO taxonomy*. New York: Academic Press.
- Chuy, M., Resendes, M., & Scardamalia, M. (2010). *Ways of contributing to a dialogue in science*. Paper presented at the 2010 Knowledge Building Summer Institute, Toronto, Canada.
- Engestrom, Y. (1999). Innovative learning in work teams. In E. Y., M. R. & P. R. L. (Eds.), *Perspectives on activity theory* (pp. 377-404). Cambridge: Cambridge University Press.
- Leng, J., Lai, M., & Law, N. (2008). *Characterizing patterns of interaction in knowledge building discourse*. Paper presented at the 16thth International Conference on Computers in Education, Taipei, Taiwan.
- Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. New York: Oxford University Press.
- Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research*, 74(4), 557-576.
- Scardamalia, M. (2002). "Collective Cognitive Responsibility for the Advancement of Knowledge". In: B. Smith (ed.), *Liberal Education in a Knowledge Society*. Chicago: Open Court, pp. 67-98.
- Scardamalia, M. (2003). Crossing the digital divide: Literacy as by-product of knowledge building. *Journal of Distance Education*, 17(Suppl. 3, Learning Technology Innovation in Canada), 78-81.
- Scardamalia, M. (2004). CSILE/Knowledge Forum. In *Education and technology: An encyclopedia* (pp.183-192). Santa Barbara: ABC-CLIO.
- Scardamalia, M., & Bereiter, C. (1991). Higher Levels of Agency for Children in Knowledge Building: A Challenge for the Design of New Knowledge Media. *The Journal of the Learning Sciences*, 1(1), 37-68.
- Scardamalia, M., & Bereiter, C. (2003). Knowledge Building. In *Encyclopedia of Education*. (2nd ed., pp. 1370-1373). New York: Macmillan Reference, USA.
- Sun, Y., Zhang, J., & Scardamalia, M. (2008). Knowledge building and vocabulary growth over two years, Grades 3 and 4. *Instructional Science*, 38(2), 147-171.
- Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *Journal of the Learning Sciences*, 18(1), 7-44.

Acknowledgement

This research was funded by a research grant from the Social Sciences and Humanities Research Council of Canada titled "Ways of contributing to dialogue in elementary school science and history." We would like to express our gratitude to the students, teachers and principals of the Dr. Eric Jackman Institute of Child Study, University of Toronto, for the insights and the opportunities enabled by their involvement.

Characterizing Knowledge Building Discourse

Jennifer Yeo, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, jennifer.yeo@nie.edu.sg
Jing Wu, Singapore Center for Chinese Language, 287 Ghim Moh Road, Singapore 279623, jing.wu@sccl.sg

Abstract: Knowledge building (KB) discourse is one of the 12 principles of Knowledge Building (Scardamalia, 2002). However, it is not clear what it is like and how it mediates knowledge building. In this paper, our goal is to characterize KB discourse by analyzing students' online and face-to-face talk as they worked together to advance the science knowledge in a nature learning activity. Arguing that collaborative argumentation is an important form of discourse in science knowledge building, we draw upon argumentation framework (Walton, 2000) to identify and demonstrate how different forms of argumentation discourse observed in this nature learning activity support knowledge building. Implications to forms of scaffolding knowledge building discourse, including technology-based environment, are drawn from the study.

Introduction

Studies on knowledge-based communities such as science seem to indicate that argumentation plays a central role in their advancement of knowledge (Bell, 2004; Knorr-Cetina, 1999; Latour & Woolgar, 1986). While this term may conjure images of aggression and opposition that might not augment well with the common values and goals that characterize knowledge-creating communities, there are other forms of argumentation that could potentially mediate the process of knowledge building. In science community, members engage in argumentation by proposing, justifying, and evaluating knowledge claims in order to legitimize claims put forward by members of the community (Latour, 1987). Andriessen (2006) refers to such forms of argumentation as *collaborative argumentation*.

However, there is little known about how such discourse type mediates advancement of knowledge. Especially in knowledge building classrooms that place knowledge creation at its center, the lack of characterization of how collaborative argumentation supports knowledge building can be problematic. Teachers may have difficulty in orchestrating argumentation or scaffolding students in this dialogic process of knowledge building. Thus it is the goal of this paper to seek a deeper understanding of what types of collaborative argumentative discourse mediate knowledge building. The research question we seek to answer in this study is "what were the collaborative argumentative discourse types that mediated knowledge building during an elementary science nature learning activity?" We draw upon argumentation framework by Walton (2000) to study face-to-face and online discourse of a group of elementary students participating in a nature learning activity as an after-school program. We identified four types of argumentation dialogue types, namely, information-seeking, deliberation, persuasive and inquiry, in the students' talk. While each individual form of argumentation may seem superficial in supporting knowledge building by itself, it is the integration of the different forms that made the advancement of knowledge possible.

Theoretical Framework

The argumentation framework by Walton (2000) is based on dialog theory by Grice (1975) to study formal and cooperative dialog. Taking argumentation as a form of formal dialog involving two people attempting to reason with each other by challenging, rebutting, questioning, building on and exploring ideas, with the goal of settling some disputed issues between two parties, it consists of three key dialogic process - opening, argumentation and closing. The opening stage frames the initial situation - the participants, the goals of dialogue and participants', the type of dialogue. In the argumentation stage, the participants make their moves either by attacking an argument, supporting an argument and raising critical questions about it. Closing stage marks the achievement of their goal. In other words, an argument can be analyzed according to the following components: participants, type of moves, sequence of moves and the goal achieved. Six types of argumentative dialog - persuasion, inquiry, negotiation, information-seeking, deliberation, and eristic, were identified. A summary of the description of the argumentation types is given in Table 1.

Table 1: Types of argumentation dialogue.

Type of dialogue	Initial Situation	Participant's goal	Goal of dialogue
Persuasion	Conflict of opinions	Persuade other party	Resolve or clarify
Inquiry	Need to have proof	Find and verify evidence	Prove (disprove) hypothesis
Negotiation	Conflict of interests	Get what you most want	Reasonable settlement

			Both can live with
Information-seeking	Need information	Acquire or give information	Exchange information
Deliberation	Dilemma or practical choice	Co-ordinate goals and actions	Decide best available course of action
Eristic	Personal conflict	Verbally hit out at opponent	Reveal deeper basis of conflict

Using the above framework for evaluating argumentation, we analyzed the discourse of a group of elementary students participating in a knowledge building activity about the decomposition of meat. We want to find out what types of argumentation dialogues supported knowledge building in a group of elementary school students.

Research Method

In this study, we looked at a group of six primary five (equivalent of Grade 5) boys from a local primary school in Singapore, taking part in an after-school enrichment program based on the pedagogical approach, Knowledge Building (Scardamalia, 2002). In one of their activities, they wanted to find out what happened when meat rotted.

Taking a case study approach in this study, this group of students was chosen for demonstrating productive knowledge advancement during their NLC activity. Video data of the students' discourse and the database of Knowledge Forum form the key sources of our data. We made use of the four factors – exchange, types and sequence of moves, and goal – that characterize formal dialogue/argumentation to analyze the dialogic exchanges taking place.

Findings

Students' ideas were found to advance from a simple idea about meat decomposition to a detailed and generalizable description about its products (e.g., smell, liquid). The process included activities such as observation of decomposition, discussion of observation, raising puzzling questions, investigations and resolution. Face-to-face show-and-tell and online forum (Knowledge Forum) mediated their social interaction. Four types of argumentative dialogues were found to have mediated the advancement of knowledge about decomposition of meat – *information-seeking*, *deliberation*, *inquiry*, and *persuasion dialogue*. We will describe how these four types of argumentative dialogues mediated this knowledge advancement in one example about the liquid found in the container of rotting meat.

Information-Seeking Dialogue

The KB activity was triggered by the presentation of the observation of decomposition of a piece of chicken meat. The presentation was mediated by the teacher's and peers' questioning about their investigation during an information-seeking dialogue. An information-seeking dialogue describes the situation when one participant wants to get information that another participant possesses. Excerpt 1 shows teacher T trying to find out what the students did when they investigated the rotting meat.

Excerpt 1: Information-seeking dialogue.

Turn	Speaker	Content
1	T	Is the container closed or is it open?
2	D & A	Closed.
3	T	So you left it closed throughout the six days?
		.
		.
		.
9	HR	I opened it like during the third day.
10	T	You opened it sometimes.
11	HR	I wanted to see what was under (...)
12	T	Shhh... sorry, I didn't get you.
13	HR	I wanted to see what was under the cover as it was wet.

Here, the teacher's skepticism about the reliability of the information given by the students (see turns 1 and 3) as she questioned them about what they had done. These turns of talk by the teacher made it necessary for the students to provide clarity (turn 3) and justification (turn 13) for the actions they had taken in the

investigation. The criticality of ideas led participants to be engaged in deciding whether the information asked for was valid or relevant or not. From the perspective of Knowledge Building, such critical disposition is an embodiment of one's epistemic agency as one articulates questions and decides on criteria to evaluate the information given in the achievement of the community's goal of how the meat rotted in this case study. This critical dialogue around the observation led to puzzling questions to be identified, in this case, the presence of liquid.

Persuasion Dialogue

With the observation of "wet" meat highlighted during the presentation, one of the areas of contention is the origin of "water" (See excerpt 2) found with the rotting meat. What ensued was a persuasion dialogue as student SZ tried to convince the other students that the "water" comes from water vapor trapped in the box. A persuasion dialogue is adversarial in that its goal is to win over the participant(s) with the other side of the argument. Thus we see student SZ trying to justify for his claim that the liquid was from water vapour that had condensed by firstly countering student A's disagreement that it is "not water vapour" (turn 65) with a repair move that "I mean water that condensed" (turn 66) and that "water vapour can condense" (turn 66). He further defended this premise by highlighting that "it (the container) has been shut" (turn 67), thus justifying that "water vapour was kept inside" (turn 68). The result of a persuasive dialogue was an expansion of a simple claim to include premises as claims/premises made were challenged.

Excerpt 2: Persuasion dialogue.

Turn	Speaker	Content
55	S1	And what was the water?
		.
		.
61	T	I think we don't call it water because we don't know whether it is water. What is the liquid actually?
62	D	I don't know whether is it discharge from the maggots or something like that.
63	A	I thought it is
64	SZ	I think it's water vapour.
65	A	No. not water vapour.
66	SZ	I mean water that condensed. Water vapour that condensed. Water vapour can condense.
67	D	But it has been shut.
68	SZ	Water vapour was kept inside.

Inquiry Dialogue

While persuasion dialogue is adversarial, inquiry dialogue is cooperative. The goal is to prove that a statement designated at the opening stage true or false or if there is insufficient evidence to prove a claim, which makes it different from a deliberation dialogue which does not carry the burden of proof.

In the case example, the inquiry dialogue arose as the discussion about the origin of "water" continued, as shown in excerpt 3. With continued uncertainty expressed over the source of "water" found with the rotting meat (see turns 78 – 86), the teacher highlighted the need for an investigation when the students casted doubt into their own hypothesis (turn 86). What follows after this exchange was an investigation planned and conducted to find out if the liquid was water, among other hypotheses they wanted to verify. In the second investigation, they used two pieces of dry meat, one placed in an open box and another in a closed box, and found that both boxes had liquid in them after two weeks. In a note they posted on Knowledge Forum, they reported that the meat in the closed box "turned gooey" while meat in the opened box "remains intact except smaller". They thus concluded that "the liquid is not formed by the maggots compared to the last experiment" and that "this experiment shows that decomposition produces liquid ..."

Excerpt 3: Orchestrating inquiry.

Turn	Speaker	Content
74	T	Ok. I think Y has a very good question. What is that water? How is it Initially it was dry right I suppose ... And there is liquid there?
		.
		.

86	SZ	Maybe it's the water vapour that condenses?
87	T	Ok yah. Like you said 'maybe'. That is a hypothesis, so you actually have to go and find out ...

Deliberation Dialogue

Another dialogue type observed in the students' talk as they advanced their knowledge is deliberation. Here, the students collectively steered group actions towards a common goal by agreeing on a proposal that can solve a problem affecting all parties concerned while taking their interests into account. Excerpt 4 shows the online discourse as students were deciding on the number of meats to use as they investigated the process of the decomposition at the start of knowledge building. With different ideas proposed on the number of meat to use (see turns 7, 23, 27), it was finally decided that "2-3 meats" would be used after deliberating on the different options.

Excerpt 4: Deliberation dialogue.

Note	Author	Date/ Time	Title	Scaffold	Content
7	HR	28 Aug 09/ 3:20 pm	Another reply		Good idea, maybe we should get several pieces of meat to observe on.....
23	D	28 Aug 09/ 3:48 pm	Several pieces of meat?	I need to understand	Why is there a need for several pieces of meat when you need only a piece of meat?
27	SZ	28 Aug 09/ 3:50 pm	D's question		what if 1 of the meat fails to rot ok thats stupid but to get more better conclusion we should get 2-3 meats

In such as instance, the goal is to merely decide on the best course of action, thus the discourse is not adversarial. A justification deemed logical to the other students was sufficient. Thus criticality of ideas put forth engages students to build their argument more convincingly with justifications without the need for aggression. What is also interesting in this excerpt is that the questions asked by student D in turn 23 was answered by student SZ instead of student HR whom the question was directed at. Such turn taking could demonstrate that the students were working on ideas rather than against each other in this argumentative discourse.

Discussion and Conclusion

This case study identifies four forms of argumentation dialogues – information-seeking, persuasion, inquiry and deliberation that mediated the advancement of knowledge about the decomposition of meat. These argumentation dialogues provide the platforms for students to put forth their ideas even if they are different or opposing (e.g., in persuasion talk whereby different hypotheses about origin of "water" was put forth), exercise their epistemic agency by deciding on criteria to judge information given (e.g., in inquiry dialogue as the criterion for evaluating hypotheses was set up), take up collective responsibility as they work collaboratively to consolidate diversity of ideas (e.g., deliberation talk over the number of meat to use) rather than hit out at their opponents, and work on improving ideas as they work through diverse and uncertain ideas (e.g., inquiry talk as they sought to find evidences to support their hypothesis). The findings did not, however, identify negotiation and eristic argumentation dialogues in the knowledge building interaction. Such dialogue types, according to Andriessen (2006), do not carry the goal of working with one another toward a common goal, and thus do not contribute much to education or knowledge building. The absence of these dialogue types could perhaps explain the productive advancement of knowledge observed in this group of students as they worked collaboratively to construct their understanding of decomposition.

The findings show that the four argumentative dialogue types observed in this case study mediated knowledge building in different ways (e.g., persuasion was to convince their peers of that the liquid was water while taking into account other's ideas and inquiry was to produce evidences to address uncertainty). By itself, it did not seem to advance the knowledge of the community much, but collectively, their whole was larger than the sum of the individual process. For example, in working on what the liquid observed in the rotting meat box was (refer to excerpts 2 and 3), teacher T's information-seeking question engaged students in putting forth different ideas (i.e., "discharge from the maggots" in turn 62 and "water vapour" in turn 64 of excerpt 2). This discourse quickly turned into one of persuasion as a result of doubts casted by a few of the students and the teacher on the claims made (refer to turns 65, 67 of excerpt 2). As the proponents defended their claims when they were continually challenged, uncertainty about their own claims was expressed, which in turn shifted the

discourse to one of inquiry as they found the need to verify their hypothesis. According to Walton (2000), such dialectical shift in which an argument that starts out framed as one kind of dialogue shifts to another as the argumentation proceeds need not be a bad thing. The subsequent dialogue that follows the former could help it move along its larger goal. In this case, we see that the outcome of this series of argumentative dialogue in the case study helped the students advance the knowledge of the community as they eventually found out that the liquid did not come from water vapour or discharge of maggots but from the meat itself when it decomposed.

An implication from this study is thus the need to orchestrate such dialogue types and its shift in Knowledge Building classrooms. The knowledge advancement we see in this case example might not have been possible if the students were left on their own accord to argue. In this case example, the teacher had played an instrumental role in orchestrating the argumentative talk and the shift from one form of argumentative dialogue to another. Here the teacher would repeat the question a student asked (e.g., excerpt 1) to elicit diversity of ideas, model criticality by evaluating information given by students (e.g., excerpt 1) or challenge students' claims or premises (e.g., excerpt 3), and ask questions to encourage students to elaborate and clarify their ideas/premises (e.g., excerpts 1 and 3). She also orchestrated the shift in dialogue types as she highlighted the students' uncertainty with their claims which moved the dialogue into one of inquiry (e.g. excerpt 3). In other words, the teacher in a Knowledge Building classroom need to model the attributes of Knowledge Building discourse by engaging in a collaborative argumentation discourse with the students, yet at the same time, they need to facilitate the argumentation discourse by encouraging students to put forward their claims, elaborate on their arguments, think critically about the ideas put forth, gather evidences to support their claims and to facilitate the shift in the discourse type as the situation is appropriate. With few online argumentation dialogue ending with a clear resolution or dialectical shifts taking place, this study also suggests that the current scaffolds in the form of sentence openers (i.e., I need to understand, My theory, This theory cannot explain, New information, A better theory) may not be sufficient to support the fluid and dynamic nature of the argumentative talk. For example, it is important to capture the premise of the other party and to build on it in a persuasive talk or to shift to another form of dialogue when the need arises (e.g., from persuasive to inquiry when different participants are uncertain of their ideas). One future direction to this study is to study ways to support collaborative argumentative dialogue in online platform more effectively.

In conclusion, this study examines the discursive practices of a group of students in a Knowledge Building community and explores the characteristics of Knowledge Building discourse through the perspective of argumentation dialogue. It argues that an integration of certain types of argumentation dialogues, such as information-seeking, deliberation, inquiry and persuasion dialogue, can mediate knowledge building activity and these dialogue patterns represent the collaborative and progressive Knowledge Building discourse as knowledge work is carried out to seek continual advancement. We acknowledge that this work on unpacking Knowledge Building discourse is merely scratching the tip of the iceberg, which we hope that there could be future build-on to this work on characterizing Knowledge Building discourse and how it can be better supported through online and physical means.

References

- Andriessen, J. (2006). Arguing to learn. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 443-460). New York: Cambridge University Press.
- Bell, P. (2004). Promoting students' argument construction and collaborative debate in the science classroom. In M. C. Linn, E. A. Davis & P. Bell (Eds.), *Internet environments for science education* (pp. 115-143). Mahwah, NJ: Erlbaum.
- Grice, H. P. (1975). Logic and conversation. In P. Cole & J.L. Morgan (Eds.), *Syntax & Semantics 3: Speech acts* (pp. 41-58). London: Academic Press.
- Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Cambridge, MA: Harvard University Press.
- Latour, B., & Woolgar, S. (1986). *Laboratory life: The construction of scientific facts*. Princeton, NJ: Princeton University Press.
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.
- Walton, D. (2000). The place of dialogue theory in logic, computer science and communication studies. *Synthese*, 123(3), 327-346.

Some Discourse Mechanisms for Knowledge Advancement in a CSCL Context

Ming Lai, Nancy Law, The University of Hong Kong, Pokfulam Road, Hong Kong
Email: minglai@hkucc.hku.hk, nlaw@hku.hk

Abstract: This paper aims to examine the discourse mechanisms that may lead to students' knowledge advancement in the context of CSCL. The online discussions of one primary (sixth-) and one secondary (tenth-) grade of students were analyzed. First of all, threads with the articulation of elaborated explanations were identified, as their appearance is considered as more indicative of the advancement of knowledge. Then by studying how students worked with the major concepts within each of the threads, three general mechanisms for knowledge advancement were found: 1) setting the conditions and limits of an idea; 2) comparing different concepts; and 3) differentiating concepts. The first mechanism could be observed quite frequently in the discourse of both grades of students while the latter two were more likely to be found in the discourse of the tenth-graders compared to the sixth-graders.

Introduction

One important research agenda in computer-supported collaborative learning (CSCL) is to analyze how learning is accomplished in interactions (Stahl, Koschmann, & Suthers, 2006). Based on the pedagogical approach of knowledge building (Bereiter, 2002; Scardamalia, 2002), this paper aims to examine the discourse mechanisms that may lead to students' knowledge advancement as expressed in their online discussion.

Knowledge Building as a Pedagogical Approach

According to Scardamalia & Bereiter (2006), knowledge building is the process through which knowledge advances in human societies, and that learning can take place in the process. It envisions a new way for organizing school education to prepare students for the knowledge society (Bereiter, 2002). In a school setting, knowledge building focuses on students' collective responsibility for the advancement of the community's knowledge and the improvement of ideas (Scardamalia, 2002). In traditional classrooms in which the interaction is mainly face-to-face, knowledge building is difficult to implement as ideas generated by students are not easily recorded for the purpose of further improvement. Thus the implementation of knowledge building in schools is usually integrated with an asynchronous online platform, the Knowledge Forum® (KF), purpose-built to create a knowledge building environment for students to make their ideas explicit in the form of notes so that they can be built onto for their continual improvement (Scardamalia, 2002).

A Concern for Knowledge Advancement

Knowledge building concerns with the knowledge advancement made by students in their inquiry. However, what constitutes a knowledge advancement is not clearly defined in the literature. According to the major works in the field (e.g., Hakkarainen, 2003; Lee, Chan & van Aalst, 2006; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007), explanation-oriented discourse is regarded as an indication of the engagement in knowledge building, as it reflects a deepening in understanding of the students compared to fact-oriented discourse. In previous studies, it has been examined the pedagogical designs which were more likely to bring about the engagement in knowledge building (e.g., Lee et al., 2006; Zhang et al., 2007; 2009). In analyzing how students might advance their knowledge, the most widely researched area is the importance of questioning. For example, in Hakkarainen's (2003) study, it was reported that explanation-oriented questions rather than fact-oriented ones were more likely to lead to deepening in students' explanations. In another study, Zhang et al. (2009) differentiated teachers' questions into "questions for ideas" and "questions on ideas", and found that the latter was more useful in helping students to deepen their understanding. van Aalst (2009) differentiated three types of discourse: knowledge-sharing, knowledge-construction and knowledge-creation, with the last one the most compatible to the theory of knowledge building. van Aalst (2009) found that the student-group with the best summary note written illustrated a discourse profile closest to knowledge-creation, which was characterized by a strong sense of community-belonging and a high proportion of explanation-oriented questions asked. However, van Aalst (2009) did not examine the process through which knowledge was advanced in his study. The discourse mechanism that may trigger students' knowledge advancement is still a research area that needs to be explored.

Method

Research Setting

The data analyzed in this study were part of the “Learning Community Project” (LCP), which was launched to promote knowledge building and support its implementation in secondary and primary schools in Hong Kong. A total of two databases, one primary and one secondary, were analyzed to see if different patterns were found. As an extended period of inquiry is needed for productive knowledge building discourse to emerge (Hakkarainen, 2003; Zhang et al., 2009), these two databases were chosen because they had the longest period of inquiry among all databases at the time the analysis was conducted. The first database composed of 41 tenth-grade students in a secondary school; they formed six groups inquiring on topics of Water Quality, Plastics, and Ideal Vehicle. The students and their teacher were both new to knowledge building. The second database composed of 44 sixth-grade students in a primary school. They formed seven groups to inquire on topics of Global Warming, Energy Crisis, and Species Extinction. Two teachers were involved in the facilitation of knowledge building in the second database. One of them and about one fourth of the students had the experience of participating in knowledge building activities in the previous year. The other teacher and the remaining students were new to this pedagogical approach. In both cases students had a period of about six weeks to conduct their inquiry. Throughout the process they had to engage in the discussion on KF.

Knowledge Forum®

The asynchronous online platform employed in this study is the Knowledge Forum® (KF), which is specifically designed to facilitate the engagement of knowledge building (Scardamalia & Bereiter, 2006). Students can contribute their questions and ideas in the form of notes, and other students could respond and further improve the ideas by writing build-on notes. In writing a note, students may use the function of “scaffolds”, which are meta-cognitive prompts in the form of word cues such as “New information”, “New idea”, “I need to understand”, and “My theory”, so that they can better identify the nature of their note content (e.g., “New information” or “New idea”), identify a knowledge gap (e.g. “I need to understand”), and build or modify their theories (e.g., “My theory”, “This theory cannot explain”, “A better theory”). Notes and their build-on notes were linked physically in the form of build-on threads. Thus within a thread, there were a series of related notes. The analyses in this study were conducted based on the contents of notes situated in build-on threads.

Data Analysis

The first step in the analysis was to identify the notes which indicated a good quality from the perspective of knowledge building. Following the widely employed analytic procedures in the literature (e.g., Hakkarainen, 2003; Lee et al., 2006; Zhang et al., 2007), the level of explanation of a note was employed as the indicator of knowledge building. The coding scheme adopted was the one developed in Zhang et al.’s (2007) study, in which a total of four levels of explanation were classified: 1) Unelaborated fact; 2) Elaborated fact; 3) Unelaborated explanation; and 4) Elaborated explanation. Notes with the descriptions of terms, phenomena, or experiences were classified as facts, while those with the provisions of reasons, relationships, or mechanisms were classified as explanations (Zhang et al., 2007). In addition to the differentiation of facts and explanations, the coding scheme also takes into consideration whether the contents are unelaborated or elaborated. On the other hand, students’ questions asked in their notes were classified as fact-oriented or explanation-oriented (Hakkarainen, 2003; Zhang et al., 2007).

As the focus of this study is on the possible mechanisms for knowledge advancement, not all of the threads were studied as they might not indicate advancement. Only threads with notes classified as “elaborated explanations”, that is, the highest level based on the coding scheme of levels of explanation, were further analyzed. The major concepts being explored in each of the threads were then identified. After identifying the major concepts, the next step was to look at how students worked with these concepts, to see whether some general mechanisms for knowledge advancement could be observed.

Results

Discussion Notes and Build-on Threads

A total of 620 and 630 discussion notes were generated by the tenth-grade and sixth-grade students respectively, which resulted in a total of 76 and 69 build-on threads respectively. Each of the threads was labelled according to the topic being explored in the thread. Examples of build-on threads found in the discourse of the sixth-graders were “Solar energy” and “Wind energy” when they were inquiring on topics of Global Warming and Energy Crisis. Examples of threads found in the discourse of the tenth-graders were “Use Ultra Violet to clean water” and “LPG (Liquefied Petroleum Gas)” when they were inquiring on topics of Water Quality and Ideal Vehicle respectively.

Levels of Explanation of Discussion Notes

Presented in table 1 was the classification of notes with different levels of explanation. First of all, it should be noted that only notes with some knowledge contents articulated were classified. Notes simply with the words, “I agree”, “We can have a further discussion on this topic”, or those with only copy and paste contents were not subjected to the classification of levels of explanation. Moreover, notes with only questions asked were classified according to the orientation towards fact or explanation rather than levels of explanation. Hence, the numbers summed across columns in table 1 were smaller than the total numbers of notes reported earlier.

It can be seen from table 1 that for both grades of students, about half of the notes classified according to their levels of explanation were unelaborated facts, and less than 10% were classified as elaborated explanations. The results suggested that the construction of explanations did not occur frequently. Hence it is especially important to examine the discourse mechanisms that might trigger the deepening in explanations.

Table 1: Distribution of notes with different levels of explanation.

Grade		Unelaborated Fact	Elaborated Fact	Unelaborated Explanation	Elaborated Explanation
Sixth-grade	Number	237	73	86	34
	%	55.1	17	20	7.9
Tenth-grade	Number	231	72	81	41
	%	54.4	16.9	19.1	9.6

Threads to Further Investigate

To further analyze the discourse mechanisms for knowledge advancement, threads with notes classified as elaborated explanations were analyzed. A total of 22 (28.9%) and 17 (24.6%) threads of the tenth-grade and sixth-grade students respectively were with notes with elaborated explanations classified. The findings suggested that not all of the threads involved the construction and deepening of explanations.

Identify the Major Concepts Explored in a Thread

The next step in the analysis was to identify the major concepts being explored in each of the threads identified in the last section. For example, in the thread of “Acid rain”, the major concepts being explored were, “neutralization”, “acidic”, “alkaline”, “pH value”, “release of heat”, and “habitat”; in the thread of “Solar energy”, the major concepts being explored were, “sunlight”, “renewable”, “cost”, “power”, “weather”, “solar energy board”, and “the saving of energy”. It was then examined how students worked with these major concepts within the thread, for identifying the mechanisms that might lead to knowledge advancement, as presented in the next section.

Discourse Mechanisms for Knowledge Advancement

In analyzing how students worked with the major concepts within a thread to make knowledge advancement, there were some general patterns observed. The three most frequently observed mechanisms for knowledge advancement were “setting the conditions and limits of an idea”, “comparing different concepts”, and “differentiating concepts”. Summarized in table 2 was the number of threads with the appearance of each of the mechanisms observed. The findings suggested that the first mechanism, that is, “setting the conditions and limits of an idea”, appeared quite frequently in the discourse of both grades of students, while the other two mechanisms seemed to appear more frequently in the discourse of the tenth-graders but not the sixth-graders. The details of each of the mechanisms will be as presented in the following sections.

Table 2: Number of threads with the three common mechanisms for knowledge advancement observed.

Students	Set conditions and limits of an idea	Compare different concepts	Differentiate concepts
Sixth-grade	9	2	2
Tenth-grade	6	9	7

Mechanism 1) Set Conditions and Limits of an Idea

For both grades of students, one frequently observed mechanism leading to knowledge advancement was the “setting of conditions and limits of an idea”. The sixth-grade students tended to discuss whether something was applicable in the place they are most familiar with, that is, Hong Kong. They usually started with the discussion of a certain form of energy; then they used the characteristics of Hong Kong, such as its weather, size, and geographical features to identify the conditions and limits of the idea related to the adoption of this form of energy. Presented in table 3 are the contents of notes taken from the build-on thread of “Wind energy” of the

sixth-grade students. The first column presents the student who wrote the note. The second column presents the scaffold used in the note; if no scaffold was used, the cell was presented as empty. The third column presents the note contents.

In the example presented in table 3, with a characteristic of Hong Kong (full of buildings) articulated, students tried to set limits of the idea of wind energy, then they continued the discussion by utilizing a geographical knowledge that it is windier in higher places to suggest that windmills might be built on the top of buildings.

Table 3: Note contents taken from the thread of “Wind energy” of the sixth-grade students.

Student	Scaffold	Note Content
G6_11		<i>“Hong Kong is a place full of buildings, I think there is not enough space for wind to blow.”</i>
G6_12		<i>“I think that if we build a wind farm beside the mountain, maybe the wind is stronger and we don’t need to build it by the side of buildings.”</i>
G6_13	New idea	<i>“Ha, interesting idea, but it is a better idea if we build it on TOP of the mountain, it will get more wind there.”</i>
G6_14	New idea	<i>“How about we make a windmill on the top of the building? When you stand up on the Alps, you feel the gale, so we can get more energy!”</i>

Mechanism 2) Compare Different Concepts

In addition to the “setting of conditions and limits of an idea”, another general mechanism for knowledge advancement observed was that students often “compare different concepts”, which was especially found in the discourse of the tenth-grade students. As presented in the contents of notes taken from the thread of “LPG” in table 4, students compared LPG (Liquefied Petroleum Gas) to Hydrogen as the suitable energy source for an ideal vehicle. Through the comparison, they explored the environmental effects of different fuels in terms of the products they produced.

Table 4: Note contents taken from the thread of “LPG” of the tenth-grade students.

Student	Scaffold	Note Content
G10_21	I need to understand	<i>“Our ideal car must use LPG?”</i>
G10_22	New idea	<i>“Yes, because it is not a new technology. It is not difficult to be used.”</i>
G10_23	New idea	<i>“There is not a must in using LPG as there are many substitutions like hydrogen, solar power and electricity. If you are concerning about the environmental effects of different fuels, then hydrogen could be better than LPG because the only product would be H₂O, or at most, oxides. However LPG will still produce carbon dioxide and nitrogen oxide.”</i>

Mechanism 3) Differentiate Concepts

Another general mechanism for knowledge advancement observed was the “differentiation of concepts”, which was more frequently found in the discourse of the tenth-grade students (see table 2). In threads with this mechanism identified, students often clarify the difference between different concepts, which might lead to the advancement of knowledge. Unlike the mechanism of “comparing different concepts” presented in the last section, in the discourse illustrating the “differentiation of concepts”, students often got confused with some of the concepts, hence in the subsequent notes these concepts were clarified and differentiated from one another. As presented in the contents of notes taken from the thread of “Acid rain” in table 5, one of the tenth-grade students said that “red tide” is toxic, then another student tried to differentiate the difference between the concept of “toxic” and that of “the consumption of oxygen”.

Table 5: Note contents taken from the thread of “Acid rain” of the tenth-grade students.

Student	Scaffold	Note Content
G10_41	New information	<i>“Some of the algae are toxic, they will make the fish die. Water may be polluted by the toxic algae and the dead fish. Some algae may produce bio-toxins. Filter-feeding shellfish, particularly the bivalves, such as scallops, oysters and mussels, can accumulate these algal bio-toxins such that they</i>

		<i>become toxic to humans.”</i>
G10_42	My opinion	<i>“In my mind, I remember that red tide is non-toxic, but it will affect the water life. It’s because red tide is a kind of algae, it needs to breathe in oxygen in order to maintain their life, so the oxygen amount in the water will be decreased. When the algae died, oxygen is used to decompose the dead body and there is a lot of oxygen consumed. The water life will be killed because of lacking of oxygen.”</i>

Discussion

Knowledge building emphasizes the advancement of knowledge made by students. However, less research has been conducted for identifying possible mechanisms for knowledge advancement. Three general mechanisms were identified in this study. They are “setting the conditions and limits of an idea”, “comparing different concepts”, and “differentiating concepts”. On Knowledge Forum®, there is a scaffold with the wording, “This theory cannot explain...”, which is closely related to the first mechanism of “setting the conditions and limits of an idea”. However, from the discourse examples taken from this study, students did not seem to reason in a way of identifying what a theory cannot explain. Rather, the sixth-grade students often started with a certain form of energy, then they tended to argue that this form of energy cannot be applied in Hong Kong because of its characteristics. In addition to the setting of conditions and limits of an idea, students can also advance their knowledge by comparing and differentiating concepts. The findings may provide pedagogical insights for the implementation of knowledge building. Getting students to compare different concepts and to differentiate concepts that they are easily confused with may be helpful for making knowledge advancement.

One limitation of this study is that the period of inquiry, which is about six weeks, may not be long enough compared to previous studies (e.g., Hakkarainen, 2003; Zhang et al., 2007), which might take several months for students to engage in productive knowledge building. It is possible that some other mechanisms for knowledge advancement could not be captured because they may take a longer period of inquiry to emerge. For example, one important principle of knowledge building is “rise above” (Scardamalia, 2002), which articulates that students should go beyond current practices, targeting at more inclusive principles and higher-level formulations of problems. However, mechanisms similar to “rise above” were not observed in this study. Although there were examples of notes that students tried to bring together different viewpoints expressed earlier, they could not take them to a higher-level. As the period of inquiry in this study may be too short for all possible mechanisms for knowledge advancement to be observed, further studies may be conducted with databases in which a longer period of inquiry is involved. Moreover, as there may be cultural differences in the engagement in knowledge building (Lai & Law, 2006), studies may be conducted in different cultural contexts to see whether different mechanisms can be observed.

References

- Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Hakkarainen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching*, 40(10), 1072-1088.
- Lai, M., & Law, N. (2006). Peer scaffolding of knowledge building through collaborative groups with differential learning experiences. *Journal of Educational Computing Research*, 35(2), 123-144.
- Lee, E. Y. C., Chan, C. K. K., & van Aalst, J. (2006). Student assessment of collaborative learning in a CSSL environment. *International Journal of Computer-Supported Collaborative Learning*, 1(1), 57-87.
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97-118). NY: Cambridge University Press.
- Stahl, G., Koschmann, T., Suthers, D. (2006). Computer-supported collaborative learning: A historical perspective. In R. K. Sawyer (ed.), *The Cambridge handbook of the learning sciences* (pp.409-426). NY: Cambridge University Press.
- van Aalst, J. (2009). Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourses. *International Journal of Computer-Supported Collaborative Learning*, 4, 259-287.
- Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in the work of 9- and 10-year-olds. *Educational Technology Research and Development*, 55, 117-145.
- Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *The Journal of the Learning Sciences*, 18, 7-44.

Dimensions of Social Interactions Contributing to Knowledge Construction and Building in an Online Learning Community

Victor Law, Xun Ge, and Deniz Eseryel, University of Oklahoma, 820 Van Vleet Oval, Norman, Ok 73019-2041

Email: vlaw@ou.edu, xge@ou.edu, eseryel@ou.edu

Abstract: A case study was carried out to understand the social interaction patterns of the graduate students in an online learning community in an instructional design (ID) course and the influence of their interaction behaviors on their knowledge construction and building in ID. Sixteen graduate students participated in this study over a semester's ID course. The analysis of online discussion logs and interviews provided us with rich data to help us examine the research questions. The findings pointed to four important factors influencing the quantity of students' online participation and contribution, as well as their engagement in the online learning community: (1) prior knowledge and experience; (2) group composition; (3) peripheral participation; and (4) guiding questions. The article is concluded with the implications for developing instructional strategies to facilitate the growth of an online learning community.

A Learning Community for an Ill-Structured Knowledge Domain

With the rapid advancement of communication technologies, numerous online learning communities have emerged in formal or informal educational settings. The goal of online learning communities is to advance collective knowledge and support the growth of individual knowledge through the advancement of collective knowledge (Scardamalia & Bereiter, 1994). According to Vygotsky's (1978) socio-cultural theory, individuals' cognitive development happens at two levels: first on the social level, and later at the individual level; first among people and later inside individuals. The proponents of learning communities argue that people learn best through social interactions and knowledge construction processes. From the multicultural perspective, our society is becoming increasingly diverse, which requires people to interact and work with people from diverse background (Bielaczyc & Collins, 1999). Therefore, the notion of learning communities is not only aligned with socio-cultural learning theory but also congruent with the changing needs of a digital age.

A learning community enables learners to engage in peer interactions, such as providing feedback, asking questions, receiving explanations, negotiate meanings, resolving conflicts, and co-constructing knowledge (Webb & Palincsar, 1996), which lead to collective knowledge construction and building. Such an environment should be motivating to engage members in working with the complexity of the ill-structured problems (Barab & Duffy, 2000) because in a learning community, members learn from an instructor and other members through considering important aspects pointed out by the instructor, reflecting on the questions and problems introduced by other members, and pondering multiple perspectives. A learning community provides affordances for learners to share their expertise through social interactions and allow them to see multiple perspectives (Brown & Campione, 1994), which is an important aspect for problem representation in solving complex, ill-structured problems (Feltovich, Spiro, & Carlson, 1996). Therefore, a learning community can be an effective instructional approach for complex and ill-structured knowledge domains such as instructional design (ID) (Rowland, 1992), in which the problems have unclear goals, unstated constraints, uncertain relationships among the problem elements, multiple solution paths, and multiple criteria for evaluating the solutions (Ertmer et al., 2008).

Given the numerous advantages of online learning for knowledge and skill development, we built a structured online learning community to enhance students' understanding and skill development of ID. Presumably, learners would participate actively in virtual learning communities to share information, construct knowledge, and develop expertise, provided with a structured and instructor-guided online learning community. However, we do not have sufficient empirical evidence to support this assumption. Most of the past research on learners' online interactions either focused on the quantity of members' contribution (Dennen, 2005) or the factors motivating members to contribute (e.g., Xie & Ke, 2009) instead of examining how learners interacted in or contributed to online discussions. Based on a literature review on possible reasons why students contribute or not contribute in online discussions, Cheung, Hew, and Ng (2008) summarized eight factors that influenced students' online participation in various conditions: non-facilitated learning environments, classes where online discussion is mandatory, or classes where discussion is non-mandatory. The eight factors are discussion topic, students' knowledge about the topic, instructor posting, participants' posting, availability of time, the ease of use of technology, and the community spirit. As such, previous studies had limited focus on investigating factors that motivate members to participate in online discussions. Little is known about how, if any, these factors may

influence knowledge construction and building in online learning communities, especially in the context of complex and ill-structured knowledge domains.

Therefore, the purpose of this study was to build on the previous studies and explore any other potential factors, particularly in the context of a course on instructional design, which is an archetypal example of a complex and ill-structured knowledge domain. In addition, we intended to understand how members participated in an online discussion that was structured and guided, how they interacted with each other, and how their interaction behaviors influenced their knowledge construction and building in ID. Specifically, we investigated the following two research questions: (1) What are the factors influencing the quantity and quality of online discussions in an online learning community? (2) How does each of these factors contribute to members' understanding of ID domain and ID skill development?

Method

Participants and Context

The participants of this study were 16 graduate students, with different education background, ethnicity, and experiences and prior knowledge about instructional design. The ID class was conducted in a blended learning environment, in which students met once a week on Monday evening for three hours. The online discussion forum served as a collaborative platform for building an online community. It was an extension of the weekly face-to-face class. The students were required to participate in the online discussion, and the instructor facilitated the weekly discussion by posting guiding questions corresponding to weekly reading assignment. At the beginning of the semester, students were assigned into three groups and they were required to participate in their own group's discussion. Although individual members had the flexibility to join in the other groups' discussion, such as viewing and posting messages, they must participate in the discussion of their home group. The students had to follow the discussion protocols, which specified that they must complete the following steps: posting an initial message, posting questions to peers and responding to peers, and in the end writing and posting a reflective summary of the week's discussion.

Data Analysis

A case study method was utilized to analyze the data from four sets of online discussion logs, five semi-structured interviews and observation notes. We employed open coding techniques to code interviews and students' online discussion logs (Shank, 2002). Interviews were transcribed and read so that patterns could be identified and coded. Then, we searched for variables by counting and clustering the codes we found. We displayed our data, such as comparing and contrasting different cases, and examining outliers to identify themes, which showed possible factors that affected the quantity and quality of online discussions. Finally, we triangulated our findings with descriptive statistics of the online discussions, interview and observation data.

Results

In response to the first research question, preliminary data analysis pointed out four important factors influencing the quality and quantity of online discussions in an online learning community. These four factors included: (1) prior knowledge and experience; (2) group composition; (3) peripheral participation; and (4) guiding questions.

The second research question asked how each of these factors contributed to students' learning in the complex and ill-structured domain of instructional design. The following subsections briefly elaborate on our findings related to the second research question.

Prior Knowledge and Experience

Consistent with the previous research (Cheung, Hew & Ng 2008; Ge & Hardré, 2010), the findings of our study showed that students' prior knowledge had a positive impact on the volume of postings in online discussions. In addition, our study also showed that students' prior knowledge on the discussion topic positively impacted the depth of discussion, quality of postings, and the amount of benefit the students were gaining from online discussions. For instance, in Week 5, during which students discussed the topic on learning assessments, there was a high level of interactions and number of message postings. We contributed this fact to students' familiarity with the topic because many students in the ID class were taking a measurement class at the same time. One of the students said, "I am taking Measurement and Assessment ... I do not refer the textbooks because pretty much all of it came out of my head". Although assessment was fairly new prior knowledge to most of the students, because the topic was still fresh and current in their minds, the students were able to engage in deeper discussion on some concepts, which later branched into multiple sub-topics, such as fairness of the assessments, purpose of the assessments, and how assessments might link to creativity and competition.

Additionally, whenever students applied the textbook knowledge to their real life experience, the online discussions became richer because these experiences served as anchor for reasoning and discussion. For

instance, Luke shared how he allowed his students to rework on their assignments in a college-level class he was teaching. Many online participants questioned the consequential validity of the assessment method, because they believed that college GPA could be used normatively in application of graduate schools. When Luke allowed his students to rework their assignments to gain better grades, those students might gain unfair advantages on graduate school admission. A thread of discussions regarding this view was generated. Luke later provided some contextual information to clarify the instructional situation. In the end, the group came into consensus with Luke's view that the assessment method he chose to use was valid, due to the particular instructional situation he later explained in the discussion,

Our study also found that student's prior experience also helped to enhance other students' learning. In an interview, Eva said that others' real-life examples helped her better understand instructional design theories. She said, "I cannot just envision things to theories... I am big in application, and this is how I learn to be able to apply the things we've discussed. And, giving real life experience or examples helps me to fully understand it."

Group Composition

The findings of our study indicated the importance of student composition with respect to their real-life work experience and other background knowledge and skills. The real-life experience shared by individuals helped their peers to develop an appreciation of the complexity of real-life ID problems and multiple perspectives of the issues being discussed, which are highly valuable learning outcomes for complex and ill-structured instructional design domains.

In addition, different members of the online community brought with them different expertise from which others could learn. For instance, Janet said: "Lily has a very good grasp of APA. And, just how to put something together. So, I can use hers as a model...Ella is a very good writer." Finally, people can also learn from others' who come from different countries. For example, an international student showed how assessment was performed in her home country, which was very different from how assessment was done in America.

Peripheral Participation

Interestingly, although international students brought with them the different cultural perspectives to a learning community, some of them were not as active in participating in online discussions as their U.S. peers, probably due to their language barriers and the new educational system and environment they had to adapt to. Their participation was generally lower than the domestic students. This makes sense because when participants did not have a feeling of connection to, or when they were not able to identify with a learning community, they were less likely to post. However, we found some peripheral participation from the international students from the online logs. Over the semester, more than 1,200 messages were posted, and two of the international students read almost every single message posted although they had posted very few messages. This finding was confirmed in the interviews. We expect that these students would gradually participate more in the learning community as they became more comfortable with the U.S. educational system and the new learning environment, as they became more connected to the learning community through social interactions, and as their confidence and competence to participate in learning activities grew over time.

The Role of Guiding Questions

Another important factor that affected students' engagement in online learning communities was the guiding questions the instructor provided to the participants. Throughout the class, students were required to read three to five chapters per week, which covered a lot of different topics. Janet said, "That's just so much in those chapters. If they were not guided, everybody just starting picking up odd things." Eva said, "I think without those, there are nothing to write. I think you really have to have some form of questions to address." These data suggested the importance of guiding questions in facilitating effective learning through online discussions. Good guiding questions not only led to fruitful online discussions, but also helped students with other aspects of the course. For instance, Zoe suggested that guiding questions helped her to focus on the readings, which, in turn, helped her to develop her final project.

Furthermore, the results of our study suggested that some types of guiding questions were more effective than others in terms of enhancing the quantity as well as the quality of discussions. For example, guiding questions that required students to synthesize what they had learned generated a lot of good discussions. When the instructor asked the students to describe the relationships among instructional theories, learning theories, and instructional design models, the students posted very interesting messages conceptualizing their thoughts through the use of metaphors and analogies. For instance, Ian used the metaphor of a pot of flower to show the relationships among the theories and models, which raised a lot of interest and invited a lot of questions from the group members. Some members asked him how he fit the three components in this metaphor, while other members suggested different ways to interpret the pot of flowers and represent the relationships among instructional theories, learning theories and instructional design models.

Another type of guiding questions that resulted in effective learning from the discussions was the questions that asked more experienced members to share their experience and understanding while asking less experienced members to ask more experienced members questions on a given topic. For example, when the instructor asked the experienced members to share their understanding of the roles and tasks of project managers and instructional designers while encouraging less experienced students to ask the experienced members the questions, the members in the learning community were given clear roles, either as experts to share their experiences in their own field or as novices to learn about the field. In such scenarios like this, the volume of postings went up dramatically, so did the depth of the online discussion.

Discussion and Implications

The findings of this study are consistent with recent studies that suggest students' prior knowledge has a positive impact on online engagement and learning (Cheung, Hew & Ng, 2008; Ge, Chen, & Davis, 2005; Ge & Hardré, 2010). The study results also confirmed de Wever and his colleagues' (2008) findings that assigning roles may enhance their engagement in the online community. In addition to the individual factors, this study provided further evidence about the effect of guiding questions, which were found to be very important in facilitating peer interactions and learning.

This study implied that peers could facilitate the development of individual understanding and skill development of a complex and ill-structured domain through social interactions in an online community. Yet, members must be scaffolded in order to lead to fruitful discussions. Although guiding questions are an effective way to scaffold students' knowledge construction and building process, it is insufficient. We also need to take advantages of students' prior knowledge and use it to scaffold their learning and be strategic in creating an environment for members to share knowledge and learn from multiple perspectives. Meanwhile, we also need to facilitate peripheral participants to move gradually to the center of learning. The findings of this study provide us with some useful insights in designing online learning communities, including the consideration of group composition and the design of guiding questions, in the context of skill development in an ill-structured knowledge domain such as instructional design.

References

- Barab, S. A., & Duffy, T. M. (2000). From Practice Fields to Communities of Practice In D. H. Jonassen & S. M. Land (Eds.), *Theoretical Foundations of Learning Environments* (pp. 25-56). Mahwah, NJ: Lawrence Erlbaum Associates.
- Bielaczyc, K., & Collins, A. (1999). Learning communities in classrooms: a reconceptualization of educational practice. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory, volume II* (Vol. II, pp. 269-292). Mahway, NJ: Lawrence Erlbaum Associates.
- Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press.
- Cheung, W. S., Hew, K. F., & Ng, C. S. L. (2008). Toward an understanding of why students contribute in asynchronous online discussions. *Journal of Educational Computing Research*, 38(1), 29-50. doi: 10.2190/EC.38.1.b
- de Wever, B., Schellens, T., van Keer, H., & Valeke, M. (2008). Structuring Asynchronous Discussion Groups by Introducing Roles: Do Students Act in Line With Assigned Roles? *Small Group Research*, 39(6), 770-794. doi: 10.1177/1046496408323227
- Ertmer, P. A., Stepich, D. A., York, C. S., Stickman, A., Wu, X. L., Zurek, S., & Goktas, Y. (2008). How instructional design experts use knowledge and experience to solve ill-structured problems. *Performance Improvement Quarterly*, 21(1), 17-42.
- Dennen, V. P. (2005). From message posting to learning dialogues: Factors affecting learner participation in asynchronous discussion. *Distance Education*, 26(1), 127-148. doi: 10.1080/01587910500081376
- Ge, X., Chen, C.-H., & Davis, K. A. (2005). Scaffolding Novice Instructional Designers' Problem-Solving Processes Using Question Prompts in a Web-Based Learning Environment. *Journal of Educational Computing Research*, 33(2), 219-248.
- Ge, X., & Hardré, P. (2010). Self-processes and learning environment as influences in the development of expertise in instructional design. *Learning Environments Research*, 13(1), 23-41.
- Feltovich, P. J., Spiro, R. J., Coulson, R. L., & Feltovich, J. (1996). Collaboration Within and Among Minds: Mastering 33333Complexity, Individually and in Groups. In T. Koschmann (Ed.), *CSCL: Theory and Practice of An Emerging Paradigm* (pp. 25-44). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Rowland, G. (1992). What Do Instructional Designers Actually Do? An Initial Investigation of Expert Practice. *Performance Improvement Quarterly*, 5(2), 65-86.
- Scardamalia, M., & Bereiter, C. (1994). Computer Support for Knowledge-Building Communities. *The Journal of the Learning Sciences*, 3(3), 265-283.

- Shank, G. D. (2002). *Qualitative research: A personal skills approach*. Columbus, Ohio: Merrill Prentice Hall.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge MA: Harvard University Press.
- Webb, N. M., & Palincsar, A. S. (1996). Group process in the classroom. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 841-876). New York, NY: MacMillan.
- Xie, K., & Ke, F. (2009). How does students' motivation relate to peer-moderated online interactions? Paper presented at the 8th international conference on Computer supported collaborative learning, Rhodes, Greece.

Context Aware CSCL: Moving Toward Contextualized Analysis

Sean P. Goggins, Drexel University, outdoors@acm.org
James Laffey, University of Missouri – Columbia, laffeyj@missouri.edu
Chris Amelung, Washington University in St. Louis, amelungc@gmail.com

Abstract: Groups change over time. CSCL groups, unlike face to face groups, leave evidence of their interactions behind in the form of system logs. Most CSCL log analysis is opportunistic, relying on electronic traces which do not provide information about use context, user content reading behavior or insights about relations among users. To enable context rich analysis of student interactions, we developed a context aware notification system (CANS). In this paper we describe how such logs are processed and analyzed to support the development of multi-mode social networks. In prior studies we reported on analysis of these networks from CANS logs and context enriched logging systems focused on the small group unit of analysis. The purpose of this paper is to increase understanding of the methods we use within the CSCL community. We use CANS logs to create awareness of the social experience of online learning and emergent group formation.

Introduction

In this concept paper we assert that theories of interaction in CSCL must incorporate a more explicit approach to the design of logging systems. Suthers (2010) describes contingency graphs as analytical mechanisms for the study of uptake in CSCL environments in a manner that does not place time at the center of analysis, but instead focuses on conditions that precede and follow important learning acts. Reimann (2009) focuses on the central importance of time, highlighting a gap in our understanding of how time is understood in long running, asynchronous interaction. Stahl (2006; Stahl, 2009b; Stahl, 2009c) focuses on the small group unit of analysis as he calls for a study of the science of group interaction (Stahl, 2009a). Our contribution exists at the intersection of these interests and efforts. We integrate Stahl's focus on the small group unit of analysis, Reimann's attention to time, Suther's analytic view of data and four years of experience using rich, context aware logs to study asynchronous, completely online CSCL environments (cited throughout). With the rest of this paper we review the literature in CSCL focused on advancing the analytical tools available in the field, describe our socio-technical framework (CANS) for more closely connecting interactions to the lived experience of users, and discuss the implications for CSCL theories.

Literature Review

Suthers (2006) called for recognition that ongoing work in CSCL requires integration of design based, phenomenological, and experimental methods to build a complete picture of the intersubjectivity of computer supported collaborative learning. Each methodological tradition is, by itself, too narrow to support the ongoing examination of the socio-technical CSCL experience that we now recognize to be munificent in its variation, even in the same population using the same set of tools over time. Specifically, Suthers (2006) points out that experimental approaches embody an artificiality that constrains our view of how learning events actually happen in the world, design based approaches take the form of iterations and lead to an emergent technomethodology (Dourish & Button, 1996) that practically celebrates munificent variation in uptake and use of CSCL ICT's, and more purely phenomenological studies of CSCL provide descriptions of what occurred. These approaches often fall short in their attempts to provide useful guidance for the development of interventions in the future.

Reimann (2009) takes another perspective on the range of methods utilized in CSCL by presenting a contrast between coding and counting CSCL events, which he calls variable focused analysis, and sequential analysis of events in CSCL settings. This work raises questions about the applicability of analysis of variables in the complex, real world settings that constitute most CSCL environments and the intersubjective learning processes they support. The observed munificent variations of CSCL experience are, to Reimann, an irreconcilable set of multivariate confounds.

As a solution this to core challenge in CSCL research, Reimann (2009) posits that analysis of events and event streams will provide a more authentic view of the intersubjective nature of learning in CSCL environments. While the conceptual insight about the importance of event logs is one we agree with, the conclusion that these events are likely to be digested into semantically meaningful process models and process model instances presumes a linearity and consistency of interaction in CSCL environments for which there is no empirical evidence. Reimann, Frerejean & Thompson (2009) test the idea of applying a process model to event data, concluding that the decision processes in fact take a different path each time. Goggins, Laffey & Tsai (2007), Goggins, Laffey & Galyen (2010a) & Goggins et al (2010b) go further in demonstrating the munificent

variations of interaction revealed by event logs. These studies show that even in the most controlled CSCL environments, no two groups follow the same processes. Specifically, those CSCL participants who experience the same CSCL curriculum in the same CSCL, socio-technical environment with the same instructor produce interaction logs with highly variable activity levels, activity sequences and following group-specific processes. This holds for groups who are able to see the activity of other groups and would therefore be at least partially susceptible to social comparison influences (Festinger, 1954) and those where groups are not able to see each others activity (Goggins et al., 2011, *International Journal of Computer Supported Cooperative Work*, Under Reveiw). Put simply, the notion of nascent, identifiable process models emerging across instances of a CSCL environment is not supported by any data we are aware of.

An alternative to process modeling is Suthers et al's (2007) concept of an eclectic model for examining the interactivity of participants in a CSCL environment. Unlike process models, the eclectic model works to incorporate multiple perspectives from different data. The events themselves are not any more richly constructed than Reimann's (2009), but they are integrated with other data to tell the story of CSCL experience from multiple methodological perspectives. Suthers et al (Suthers et al., 2007) explicate the construct of a dependency graph, which they use as an analytical boundary object for integrating event log data with data from other data types and research methods commonly used in CSCL research. Like Reimann, Suthers et al arrive at a method of examining behavior in logs that relies on establishing a more defined, non-dynamic picture of interaction than what is born out by much experience in the socio-technical systems that constitute CSCL in the wild. The important contribution of the dependency graph in CSCL research is that it facilitates consistent integration of data from the diverse set of research traditions used to examine CSCL.

Eclectic modeling and dependency graphs used as boundary objects raise the question of whether or not existing systems for logging CSCL activity provide sufficient contextual data to support an automated approximation of a dependency graph. Is it possible more context data could be captured in logs than is commonly the case in CSCL today? If we did this, could the automated generation of dependency graphs that are more easily integrated with other forms of CSCL data be realized? The interactive logs we analyze provide the bidirectional view of interaction through technology in a learning environment that is not available for the analysis methods proposed by Reimann (Reimann et al., 2009) and Suthers (Suthers et al., 2007). The logs produced by the CANS system (our unique logging system, described under study context and methods), in fact, provide a wider swath of interaction data for analysis, and as a consequence greater potential for automated analysis of interactivity in computer mediated learning settings. For example, our preliminary analysis of interaction logs over three years of CANS data shows that these sorts of passive, invisible interactions between members are more common than post behaviors by a ratio of 15:1 (6.6% of activity in ~670,000 events is active, posting or creating activity). To understand the uptake of ideas in these environments, CANS logs provide a wide foundation of interactivity records that we will use for the development of insight from events, event vocabularies and event grammars (event vocabularies and grammars are discussed in more depth later in this section).

Our work seeks to elaborate on Suthers et al's (2007) notion of the dependency graph by incorporating a more complete logging infrastructure, and analysis that recognizes the evolving social structures and patterns that can be made visible through these logs. Most significantly, the logs we use capture both passive (reading) and active (posting) behavior of participants. Both Reimann & Suthers et al's approaches rely on the analysis of interactions and interaction logs that only contain a record of the proactive posting behavior of participants. This proactive posting behavior, in response to others and sometimes starting from scratch (as in a new forum) describes the observable, creative acts of participants. Prior research in online awareness (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003; Carroll, Rosson, Convertino, & Ganoë, 2006; Amelung, 2007; Laffey, Amelung, & Goggins, 2009) across multiple contexts suggests that knowledge of the social presence (Erickson & Kellogg, 2000) of others influences interaction. In CSCL environments, knowledge of who is reading the contributions of which other participants permits the researcher to observe the full intersubjective nature of interactions, and tease out the vocabularies and grammars of interaction which correspond with different levels of performance.

Our work views this less active behavior as a significant but typically invisible indicator of uptake in CSCL environments. As an example, imagine an individual in an online graduate student course who is contributing to a discussion in her small group. The participation in this course occurs in course wide discussion boards and through discussion boards restricted to each small group. Our subject is participating in a design activity with her small group while at the same time contributing to a question posed by the instructor of the course, asking students to list a design researcher whose work is exemplary of the type of work she would like to do. If we know that the student is reading the posts of other students in the larger context consistently before she makes contributions to her small group, we have evidence that the meaning making (uptake) is influenced not only by her direct response to her group, but also by her sequential review of other material in the course. If we extend our view of the uptake of information to include other interactions of the member with

information resources or colleagues outside the course, it quickly becomes apparent that our view of uptake is materially influenced by the width of data we capture.

Our work adapting Suthers et al's (2007) notion of uptake emerges as a two-step interpretive dance. The first step is analyzing sets of log data that permit a researcher to witness emergent social structures, combined with the full indexicality of socio-technical interactions – active and passive. This will potentially change both our view of the nature of mixed methods research in CSCL, but also expose the potential richness of member event grammars that may be constructed from these logs. As we noted earlier, passive actions outnumber active actions in the systems we have studied by a ratio of 15:1. Our logs provide 15x more data for constructing event grammars. As a second step outside the scope of this paper, but important to our long term research agenda, capturing log data from multiple socio-technical contexts to reflect the actions of a group of CSCL users will widen our view of indexicality and possibly introduce a new set of CSCL patterns.

For electronic trace data, the small group unit of analysis truly becomes, as Stahl (2006) states, “Where the action is” in CSCL. Traces measure interactions between a user and a system; CANS captures more context data than any other system and from that data we can reconstruct the multi-modal social network experienced by students and instructors.

Which Log Structures are Analytically Useful?

Conversation analysis from the ethnomethodological tradition and social network analysis from structural sociology contribute theoretical and methodological perspectives to our work defining log analysis and log design in CSCL. The context data and completeness of the interaction record that is revealed by CANS log data is also foundational to our ability to proceed with a study that explores the utility of log and sequence structures for CSCL research. Our goal here is to discover new ways of analyzing electronic traces by identifying semantically meaningful grammars from event trace data in CSCL environments. CANS is the first system we are aware of which has collected at least five years of rich trace data from completely online learning groups.

Research methods like conversation analysis have examined the microstructure and indexicality of conversation to explicate meaning. The events we record and grammars we identify are derived from socio-technical interactions recorded in CANS event logs from an online course management system. While conversation analysis has a long tradition of examining micro-sequences of conversation to explicate meaning and understand the perspective of conversational participants, our method is new. In conversation analysis, the sequential order of utterances and non-verbal communication are viewed together with a particular expression, word or phrase to discern meaning. In CSCL, the Virtual Math Teams research led by Gerry Stahl (Stahl, 2006; Cakir, 2007; Stahl, 2009c; Stahl, Ou, Cakir, Weimar, & Goggins, 2010) demonstrate the applicability of methods derived from conversation analysis and ethnomethodology to the analysis of socio-technical conversations around objects in a synchronous CSCL space.

We show that insights about structural change and interesting events emerge from our log analysis, and suggest that CSCL researchers who use conversation analysis will benefit from first applying our methods as a filter for selection of specific events for coding. Readers should note that we think that obtaining the richness of understanding that emerges from ethnomethodologically informed methods, like those used on the VMT project through automated means, is an unrealistic goal. Without the benefit of close, interpretive examination of discourse there is certain to be loss in meaning, which is a natural outcome of choosing a vocabulary of events and event grammars, which are required steps in the production and analysis of electronic trace data.

To begin to accomplish an approximation of the understanding derived through conversation analysis from automated analysis of logs, we need to identify meaningful structures and sequences (grammars) from the available logged events (vocabularies). The construction of semantically meaningful events begins with a vocabulary of logged event types, and a search for social structural patterns (who relates to who), the trajectory of evolution in social structure and a complementary analysis of interaction sequences across the socio-technical context, which includes the layers of the system context. Events, however they are defined, are initially captured at some imperfect, but consistent granularity that works to mute subtle gestures, references and turn-taking activities that constitute the actual, qualitative experience of conversation in the electronically mediated or real world.

Event grammars built up from event vocabularies do not hold enough information to permit us to approximate the results of conversation analysis research methods through automated log analysis. We must also connect performance within groups to the structural patterns and sequences of interaction made visible through our bidirectional usage logs in order to connect events to our understanding of uptake in CSCL.

The analyzed events then become inputs to a multi-modal social network, which can be analyzed using context enhanced forms of social network analysis, which we describe in Goggins, Laffey & Gallagher (2011)

Trace Data Resolution Levels

Our insight, derived from years of analysis and active participation in the field of CSCL suggests that how logs are structured at runtime, and for analysis, can represent the lived interactions of users through technology to

greater and lesser degrees. In table one, we propose four data resolution levels for CSCL researchers to consider. The lowest level simply includes a user id, environment code, context id, session id, url, event type (read, post, etc), event object and a timestamp. Events are captured serially from the CANS system, and modified to support this analysis in each subsequent level. The expanding structure of capture and analysis described in table one is somewhat abstract, but reflects a clear description of how each progressive step provides the CSCL researcher with a more fine grained view of the experienced interactions of users. Access to the corresponding, generalized toolset will be made available as part of a conference presentation.

Table 1: Data resolution levels for CANS data analysis.

Data Resolution Level	Data Resolution Level Description
(1) Raw CANS Data	One event per row.
(2) Bi-Directional CANS Data	For example, if I read a discussion board topic that you created, then a connection is drawn between you and I. In addition to the data in "Raw CANS Data", this data set contains: <ol style="list-style-type: none"> 1. The distance in minutes between an event and the object (usually a discussion board) that the event is in response to. 2. An identifier for the object creator; this creates the social link.
(3) Exploded Bi-Directional CANS Data	Exploded Bi-Directional CANS data, as explained in Goggins, Laffey, Amelung & Gallager (2010b) and referenced in Goggins, Galyen and Laffey (2010a) recognizes the social form of online discussion. This includes recognition that when an individual participates in a discussion board or other interaction in a CSCL or other collaboration system, they frequently view more than one, specific post. This varies by environment. Effectively, one row is created for each artifact that is visible on a page when the page is viewed. In the systems we study, this is discerned from the timestamp, url and event object (artifact or discussion).
(4) Weighted Extraction of Exploded Bi-Directional CANS Data	The calculated time distance at level three can be transformed into a meaningful weighting factor for the analyst, depending on how other data gathered suggests weights should be calculated. This provides a concrete, automated method to support dependency graph construction with more refined weighting. For example, in many of our studies, interviews and field notes suggest a 3 to 4 day "cliffing" of the interaction weights is appropriate. These weighting "cliffs" depend on the environment studied.

Implications for Theory and Conclusion

The log capture and design techniques that we conceptualized in this paper provide a representative view socio-technical context in CSCL, and advance a broad range of CSCL research agendas. Data captured by most systems is designed for the convenience of system analysts and web based metrics, not for the analysis of social, collaborative behavior. CSCL log data should be analytically useful, and it should represent social interactions that are both implicit and explicit. Time matters because more recent interactions are more salient for measuring the social nature of asynchronous interaction. Activity and context matter for connecting analytical dots, as Suthers, Reimann and Stahl all do. The analysis and capture we propose here takes a more full account of activity. For knowledge construction, performance and other questions in CSCL research, the full social context is critical. For our work, and the work of those in CSCL who have turned toward the social, the log analysis we propose here is a necessary and fundamental shift required when log analysis is a central method. We think our approach complements the recent methodological and analytical innovations of others in CSCL. The techniques and tools we have developed and describe here enable CSCL researchers to more fully incorporate social theories of learning (Bandura, 1977) into their work, because our approach makes the social visible.

References

- Amelung, C. (2007). Using Social Context and E-Learner Identity as a Framework for an E-Learning Notification System. *International Journal on E-Learning*, 6(4), 501-517.
- Bandura, A. (1977). *Social Learning Theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Blincoe, K., Valetto, G., & Goggins, S. (2011). *Leveraging Task Contexts for Managing Developers' Coordination*. Proceedings from ACM International Conference on Software Engineering, Hawaii.
- Cakir, M. P. (2007). *How online small groups create and use mathematical objects to do collaborative problem solving*. Proceedings from Proceedings of the 8th international conference on Computer supported collaborative learning.
- Carroll, J. M., Rosson, M. B., Convertino, G., & Ganoë, C. H. (2006). Awareness and Teamwork in Computer Supported Collaborations. *Interacting With Computers*, 18, 21-46.

- Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: synchronizing task-oriented collaborative activity. *International Journal of Human-Computer Studies*, 58, 605-632.
- Dourish, P., & Button, G. (1996). Technomethodology: Paradoxes and Possibilities. *Proceedings of CHI96 Human Factors in Computing Systems*, 13-18.
- Erickson, T., & Kellogg, W. A. (2000). Social Translucence: An Approach to Designing Systems that Support Social Processes. *ACM Transactions on Computer-Human Interaction*, 7, 59-83.
- Festinger, L. (1954). A Theory of Social Comparison Processes. *Human Relations*, 7, 117-140.
- Foster, J., & Goggins, S. (2011). Infrastructuring New Media for Education. *Journal of the American Society for Information Science*, under review.
- Goggins, S., Laffey, J., Galyen, K., & Mascaro, C. (2011). Group Awareness in Completely Online Learning Groups: Identity, Structure, Efficacy and Performance. *International Journal of Computer Supported Cooperative Work*, Under Review.
- Goggins, S., & Erdelez, S. (2010). Collaborative Information Behavior in Completely Online Groups. In J. Foster (Ed.), *Collaborative Information Behavior: User Engagement and Communication Sharing*. Hershey, PA: ISI Global.
- Goggins, S., Galyen, K., & Laffey, J. (2010a). *Network Analysis of Trace Data for the Support of Group Work: Activity Patterns in a Completely Online Course*. Proceedings from ACM Group 2010, Sanibel Island, FL.
- Goggins, S., Laffey, J., & Gallagher, M. (2011). Completely Online Group Formation and Development: Small Groups as Socio-Technical Systems. *Information Technology & People*, Accepted.
- Goggins, S., Laffey, J., & Tsai, I.-C. (2007). *Cooperation and Groupness: Community Formation in Small online Collaborative Groups*. Proceedings from Proceedings of the ACM Group Conference 2007, Sanibel Island, FL.
- Goggins, S., & Mascaro, C. (2011). Context Matters: ICT's Effects on Physical, Informational and Cultural Distance in a Rural IT Firm. *The Information Society*, under review.
- Goggins, S. P., Laffey, J., Amelung, C., & Gallagher, M. (2010b). *Social Intelligence In Completely Online Groups*. Proceedings from IEEE International Conference on Social Computing, Minneapolis, MN.
- Laffey, J., Amelung, C., & Goggins, S. (2009). A Context Awareness System for Online Learning: Design Based Research. *International Journal on E-Learning*, 8(3), 313-330.
- Laffey, J., Tsai, I.-C., Amelung, C., Hong, R.-Y., Galyen, K., & Goggins, S. P. (2011). The Role of Social Information for Social Ability, Sense of Community and Satisfaction in Online Learning. *Journal of Open and Distance Education Research*, Accepted.
- Mascaro, C., & Goggins, S. P. (2011). *Brewing Up Citizen Engagement: The Coffee Party on Facebook*. Proceedings from Communities & Technologies, Brisbane, Australia.
- Reimann, P. (2009). Time is precious: Variable-and event-centred approaches to process analysis in CSCL research. *International Journal of Computer-Supported Collaborative Learning*, 4(3), 239-257.
- Reimann, P., Frerejean, J., & Thompson, K. (2009). *Using Process Mining to Identify Models of Group Decision Making in Chat Data*. Proceedings from CSCL 2009, Rhodes, Greece.
- Stahl, G. (2009a). *For a science of group interaction*. Proceedings from Proceedings of the ACM 2009 international conference on Supporting group work.
- Stahl, G., Ou, J. X., Cakir, M. P., Weimar, S., & Goggins, S. (2010). *Multi-User Support for Virtual Geogebra Teams*. Proceedings from GeoGebra NA2010, Ithica, NY.
- Stahl, G. (2006). *Group Cognition: Computer Support for Building Collaborative Knowledge*. Boston, MA: MIT Press.
- Stahl, G. (2009b). Meaning Making in VMT. *Studying Virtual Math Teams* Retrieved July 2, 2009, from <http://www.ischool.drexel.edu/faculty/gerry/vmt/book/26.pdf>.
- Stahl, G. (2009c). Toward a Science of Group Cognition. *Studying Virtual Math Teams* Retrieved July 2, 2009, from <http://www.ischool.drexel.edu/faculty/gerry/vmt/book/28.pdf>.
- Suthers, D., Dwyer, N., Medina, R., & Vatrappu, R. (2007). *A framework for eclectic analysis of collaborative interaction*. Proceedings from Proceedings of the 8th international conference on Computer supported collaborative learning.
- Suthers, D. D. (2006). Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 315-337.
- Suthers, D. D., Dwyer, N., Medina, R., & Vatrappu, R. (2010). A framework for conceptualizing, representing, and analyzing distributed interaction. *International Journal of Computer-Supported Collaborative Learning*, 5(1), 5-42.

Capturing and Analysing the Processes and Patterns of Learning in Collaborative Learning Environments

Kate Thompson, Shannon Kennedy-Clark, Lina Markauskaite, Centre for Computer Supported Learning and Cognition, University of Sydney, Sydney, Australia,

Email: kate.thompson@sydney.edu.au, shannon.kennedy-clark@sydney.edu.au,
lina.markauskaite@sydney.edu.au

Vilaythong Southavilay, School of Information Technologies, University of Sydney, Sydney, Australia,
vstoto@it.usyd.edu.au

Abstract: This paper describes our methodological experiences capturing and analyzing student learning processes and patterns in three cases. Agent-based models and a virtual world were used for learning. Several specific features tie these cases together and distinguish our analysis from other studies in the CSCL domain. First, students interacted in real-time for relatively short periods. Second, they interacted with each other and with interactive software tools that dynamically ‘shaped,’ and were shaped by, their learning process. Our work builds upon and integrates process analytic approaches of dynamically captured video and computer screen activity and automatic e-learning process analysis techniques. The first two cases identify areas in which analysis ‘by hand’ of small amounts of data has produced findings of initial interest. The third case discusses the use of an automatic pattern discovery technique based on Hidden Markov Models to begin to apply these methods to larger data sets in CSCL environments.

Introduction

Research on computer-supported collaborative learning (CSCL) has made significant progress in capturing and analysing student communication and decision-making processes in collaborative learning environments. In particular, this can be said about the number of studies that have explored how students navigate, communicate and collaborate in asynchronous learning management systems (Dringus & Ellis, 2005; Macfadyen & Dawson, 2010). Similarly, significant progress has been made in capturing and exploring human-computer interaction with learning software. These methods range from capturing and analysing software log files, to video observations, screen recordings, and eye-tracking traces (Cox, 2007; Derry, et al., 2010). The main enabler of this type of research is a variety of digital traces of students’ interaction within and with software, captured in digital media. As the NSF’s Taskforce on Cyberlearning report indicates, these learning traces could “aid researchers in developing a more complete and accurate scientific understanding of what makes learning most productive and enjoyable” (Borgman, et al., 2008, p. 26).

The field of CSCL encompasses a variety of scales, methods of collaborating, and media (Dillenbourg, 1999). Thus, CSCL researchers inevitably have to deal with very diverse (often multimodal) data and, as Strijbos and Fischer (2007) argue, such research often demands the integration of different analytical techniques. The use of Hidden Markov Models (HMMs) (Rabiner, 1989) is one technique that can be used to discover behavior patterns of student collaboration and interaction. Based on a sequence of activities, which can be captured in students’ trace data or log files, the HMMs can extract the states that students go through as well as the transitioning probabilities among these states. A student’s problem-solving behaviors and patterns can then be derived by analyzing the activities associated with the states and the state transitions.

The advantages of studying the processes of interaction in CSCL research are regularly discussed and the links with learning outcomes often made (for example, Cox, 2007). Less common is a simultaneous analysis of the process of student discussion with each other and dynamic interaction with the *software tool* used for learning (Thompson & Reimann, 2010). The integration of these two areas provides the focus for this paper.

Our aim is to illustrate how student interaction analyses using automatically captured data could be further extended. We will present two earlier studies that have used computer screen capture to analyze collaborative decision making and strategies for interaction with a software tool. We conclude with a recent pilot study in which student interaction patterns with software have been extracted automatically using HMM.

Case Study 1 - Collaborative Decision Making

This case study focuses on the use of screen recording software (*Camtasia*) in a virtual world (*Virtual Singapura*), which allowed the recording of both a video of students’ use of the tools and the interaction between students in a dyad. We recorded the in world actions of four post graduates and eight undergraduates. *Virtual Singapura* is a virtual world that is based on disease epidemics in 19th Century Singapore. The participants were provided with a paper-based activity that focused on reducing cholera in the city. The participants completed their in-world activity in pairs. The activity took approximately 40 minutes to complete.

The recordings provided three sources of information: audio, video and screen shots. The audio transcriptions were coded according to a modified version of the Decision Function Coding System (DFCS) (Poole & Holmes, 1995). The DFCS has seven main categories: 1) problem definition; 2) orientation; 3) solution development; 4) non-task; 5) simple agreement; 6) simple disagreement; and 7) implementation. Category Solution Development (3) has five subcategories: 3a solution analysis, 3b solution suggestions, 3c solution elaboration, 3d solution evaluation, 3e solution confirmation.

Camtasia captured pertinent information regarding the aspect of the environment that the learners were focusing on (Mazur & Lio, 2004). Many processes were represented by an action rather than a verbal interaction. Activity sequences were recorded and the process sequences mapped. Figures 1 and 2 demonstrate the main processes that pairs engaged in, in order to arrive at problem solutions.

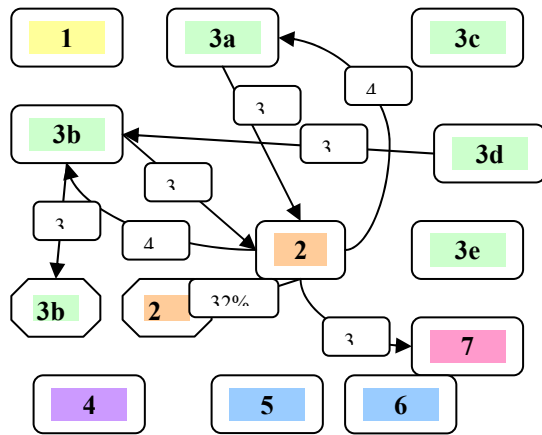


Figure 1. Group 1 Decision Making Processes.

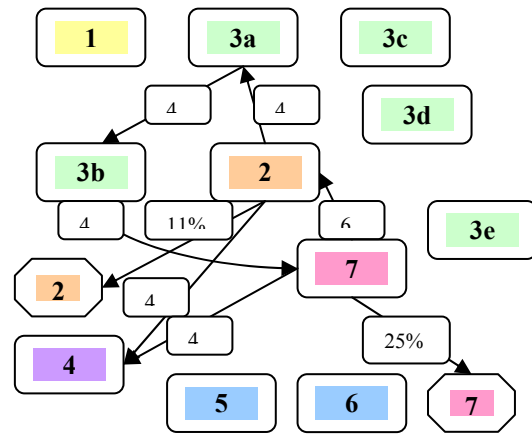


Figure 2. Group 2 Decision Making Processes.

The results of the analysis indicated that groups that were successful at arriving at a conclusion were more likely to use orientation processes (code 2) as a means of directing the group. The highest proportion of events tended to be an orientation event followed by a subsequent orientation event. The groups that did not arrive at a successful conclusion (e.g. Group 2 see Figure 2) were more likely to have non task events, such as talking about another subject. More detail on these findings can be found in more detail in (Kennedy-Clark, Thompson, & Richards, accepted). The opportunity to relate the synchronous collaboration data to the information about the interaction with the virtual world provided insights into the design and scaffolding required in this inquiry-learning task. However, coordinated analysis of data was time-consuming.

Case Study 2 - Collaborative Use of Agent-based Models

In this case, the main focus is the identification of strategies that students use to interrogate agent-based models. As with Study 1, the recording of the data and the identification was performed manually. Video screen shots were collected from two dyads of year 9 school students and coded with respect to times, activities and screens. This study used an agent-based model built in NetLogo (2010) which focused on the impact of visitors in a National Park (Thompson & Reimann, 2010). Information on the use of the model, such as the screen accessed (information or experiment), the number of times each of the three variables was changed, the model was run and the total activity (including these and other activities not discussed here) were also recorded, as was time off-task. The patterns were classified according to Levy and Wilensky's (2005) strategies (see Table 1).

Table 1: Strategies of exploration in agent-based environment found in Levy and Wilensky's (2005) study.

Name	Strategy		
	Straight to the point	Homing in	Oscillating
Overall observation time	Lower	Lower	Higher
Observation time per run	Higher	Lower	Lower
Time between actions	Higher	Lower	Lower
Runs	Lower	Higher	Medium

The time observing the model was taken as the time spent on the experiment screen. The time spent observing the model in each setting was calculated by dividing the total time spent observing the model by number of times 'go' was selected. The time spent off-task and spent reading the text/instructions were added as a result of a pilot study. The number of runs was equal to the number of times 'go' was selected. Time per

action was calculated by dividing the time observing the model by the number of changes made, and the number of changes made was equal to the total activity.

Table 2: Patterns of use of the two dyads.

Strategy	Group 1	Group 2
Observation		
Time observing the model	16:20 (Higher)	14:01 (Medium)
Time observing the model in each setting	2:43 (Higher)	2:20 (Medium)
Time spent off task	0:00	2:32
Time spent reading text / instructions	3:40	3:23
Explorativeness		
Number of runs	6 (Medium)	6 (Medium)
Action		
Time per action	0:43 (Medium)	0:32 (Medium)
Number of changes made	23 (Medium)	26 (Medium)
Pattern	Oscillating	Oscillating

Table 2 presents results of two dyads. In these two groups only the oscillating (the model oscillates between two regimes, back and forth between high and low values) strategy was identified (other strategies are reported in (Thompson & Reimann, 2010)). The strategies used by students to change the three variables were also determined using graphs of the changes in addition to the parameters outlined above. As part of this study, preliminary work was carried out that found qualitative relationships between the types of observations recorded by students in the answers to post-test questions and the oscillating strategy that was used to interrogate the model. An advantage of using agent-based models is that students are able to identify links between levels of a system (Stieff & Wilensky, 2003) - the ability to examine *how* students use these models helps to discover learning gains. This is another instance where the coordinated analysis and collection of this data was time-consuming. In order to find useful patterns and relationships, a larger sample size is required. The automated collection of log-files that record key-strokes can aid this, but the discovery of patterns of use is still nascent. The following case reports an initial investigation of students' problem-solving strategies using HMM.

Case Study 3 - Exploring Students' Problem-solving Strategies from Log Files

In this section, we demonstrate automated process analysis techniques of students' problem-solving behaviours. A pilot study was conducted to analyse sequences of students' activities in solving scientific problems. Six students were asked to use an agent-based model built in NetLogo, similar to the models described above, however the emphasis was on learning physics (Coulomb's law) (Sengupta & Wilensky, 2005).

Each student had two screens adjacent to each other: an information screen and an experiment screen. On the information screen, students entered the results of their experiments and the answers to the activities. On the experiment screen, students explored the strength of the attractive force and the distance (movement) between two charges (q_1 and q_2). Students were able to change several parameters: the value of the charge, the fade-rate value, the permittivity value, and the speed of the simulation. After setting up the two charges, students could run the simulation by pressing the GO button and then moving q_2 around in the model using the mouse.

The video screen shots, recorded with *Camtasia*, were manually coded into log files of students' activities. Each record consisted of the student action, the timestamp, and the screen on which the corresponding action happened. In the next step students' interactions with the models were re-coded as one of 14 activities: SE (set-up); GO (go); CC (change charge); CP (change permittivity); CR (change fade-rate); CS (change speed); CL (click on screen); MQ (move q_2); SQ (stop move q_2); TA (type answer); TT (type in table); DT (delete table); TE (inactivity on information (text) screen); and MO (inactivity on experiment (model) screen). We intentionally included inactive events (pauses) on the information and experiment screens as they represented events when students observed the models without changing any configuration or setup (experiment screen) and read the text without typing anything (information screen).

The generated sequences were used to derive student activity patterns. The HMM generating algorithm described in Jeong et al. (2010) was applied. Two derived problem-solving process patterns - a model-oriented (M) and text-oriented (T) - are depicted in Figures 3 and 4. Each HMM is made up of a set of states: the student activity patterns (the output probability) associated with each state and the transition probabilities between states. For example, the M student in the B state focused on the Netlogo model screen 32% of the time, and explored the model by moving the q_2 charge around and stopping the charge after moving it 68% of the time (34% each for moving and stopping activities). The probability associated with a link between the two states indicates the likelihood of students transitioning from one state to another. For instance, the M model predicts that in the B state: after the student explored the model by focusing on the model screen, moving the charge and

stopping the exploration, the student then entered the results and answers with a likelihood of 28%, restarted the model execution with a likelihood of 2%, changed the parameters with a likelihood of 2% or remained in the same state with a likelihood of 67% (i.e. the student continued exploring the model with the same setting).

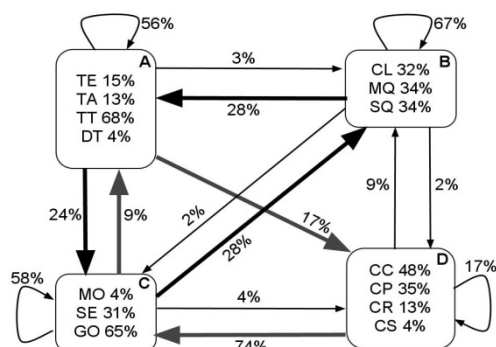


Figure 3. HMM of the Model-oriented Student (M).

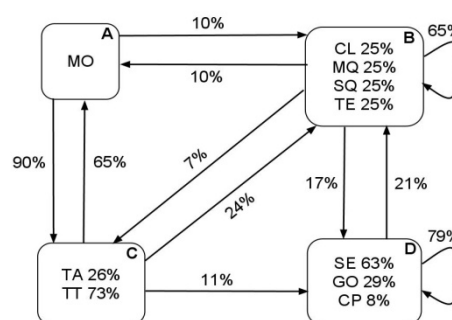


Figure 4. HMM of the Text-oriented Student (T).

We investigated the two HMMs, M and T, to gain insight into how both students solved problems. Although both models have four states, they have different structures: activities associated with each state and the state transition behaviours. We labelled the states of both models according to the activities associated with each state. The M model consisted of the following states: text (A), exploration (B), experiment setup/execution (C), and parameter configuration (D). The T model had one state (A) consisting of only one activity, MO, which represented an inactive event (pause) on the experiment screen. It also combined parameter configuration and experiment setup/execution states into one state because it had only one configuration activity, CP, which was in the same state (D) as GO and SE. Overall, the T model had the following states: inactivity/observation (A), exploration (B), text (C), and experiment setup/configuration/execution (D).

Figure 3 shows the two major paths that the M student was likely to go through in solving the problems: D-C-A-D and C-B-A-C. In the D-C-A-D path, the student started the activities with parameter configuration (state D) and then ran an experiment (C). The student then entered the results in the table (A) before returning to parameter configuration (D) to set up and run another experiment. This D-C-A-D path shows the activity pattern of parameter configuration and experiment execution. The C-B-A-C path represents the pattern of exploratory activities. When running the experiment (state C), instead of entering data into the table provided, this student explored the distance and the forces between the charges (B) before noting down the results and answers (A). The student was then likely to set up and restart the experiment in order to explore more. It was interesting to note the high transition probabilities of the loops in states B (67%), C (58%) and A (56%), compared to D (17%). When the student arrived at state B, they spent some time engaging in exploratory activities before moving to the next state. The student also spent a considerable amount of time setting up the charges before the experiment (C) and entering information and answers (A).

In contrast, there was no obvious path that the T student followed while attempting to solve the problems. Figure 4 indicates that the transition probabilities of the loops of states D and B were quite high at 79% and 65%, respectively. Although the T student spent a lot of time setting up and running the experiments (D) and exploring the forces and distances between charges (B), they often used the same parameter configurations. In addition, states B and D were coupled closely to each other: when the student was at D they would either remain in that state or transfer to B and after some time the student was more likely to transfer back to D. Although the student did read the questions in the information screen (i.e. TE activity in state B), this student did not note down the results in the table. After conducting an experiment (B and D), this student was likely to move to the table and answer the questions (C) by either passing through state A or transferring directly from D to C. However, when entering information into the table, the student was likely to stare at the experiment screen without changing the model, and then return to the table. This was indicated by the high transition probabilities from A to C (90%) and from C to A (65%).

The M and T models are two of the common behavior patterns found in this initial analysis. Further identification of the strategies described in Study 2, and determination of the relationship between these and learning outcomes are needed. In future work, we plan to collect more detailed log file data automatically which will allow us to build more elaborated patterns of student model use and collaboration.

Discussion and Conclusions

We discussed three case studies that demonstrate several approaches for the analysis of student interactions with software and between collaborating students. We showed the possibilities of integrating screen capture data with the automatic discovery of processes patterns. In study 1, screen recordings allowed the simultaneous analysis of

interactions both within the dyad and with the MUVE. We were able to code recordings using the DFCS and analyze student collaboration and decision making in the MUVE. The integration of verbal and screen capture data in this case resulted in a better understanding of the decision-making of the dyads than if only the discussions were analysed. In study 2, the analysis of screen capture data allowed important relationships between student strategies of interacting with agent-based models and particular learning outcomes to be established. Study 3 demonstrated the way in which we can use the automatic discovery of processes patterns, and what such patterns could indicate about student learning strategies. To this end, we demonstrated several of the possibilities of the use of HMM to extract students' problem-solving behaviors. All three cases together illustrated that such process analyses may allow us to understand how students *learn* in CSCL environments and what kind of learning processes various combinations of particular collaborative pedagogies and computer supported learning environments can afford.

References

- Borgman, C. L., Abelson, H., Dirks, L., Johnson, R., Koedinger, K. R., Linn, M. C., et al. (2008). *Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge*, A 21st Century Agenda for the National Science Foundation. Arlington: NSF Task Force on Cyberlearning.
- Cox, R. (2007). Technology-enhanced research: educational ICT systems as research instruments. *Technology, Pedagogy and Education*, 16(3), 337 - 356.
- Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., et al. (2010). Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences*, 19(1), 3 - 53.
- Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and Computational Approaches* (pp. 1-19). Oxford: Elsevier.
- Dringus, L. P., & Ellis, T. (2005). Using data mining as a strategy for assessing asynchronous discussion forums. *Computers & education*, 45(1), 141-160.
- Jeong, H., Biswas, G., Johnson, J., & Howard, L. (2010). Analysis of productive learning behaviors in a structured inquiry cycle using hidden markov models. Paper presented at the International Conference on Educational Data Mining.
- Kennedy-Clark, S., Thompson, K., & Richards, D. (accepted). Collaborative problem solving processes in a scenario-based multi-user environment. Paper presented at CSCL 2011, 9th International Conference on Computer-Supported Collaborative Learning.
- Levy, S. T., & Wilensky, U. (2005). An analysis of student' patterns of exploration with NetLogo models embedded in the Connected Chemistry environment. Unpublished draft to be presented at the 2005 annual meeting of the American Education Research Association, Montreal, Canada. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
- Macfadyen, L. P., & Dawson, S. (2010). Mining LMS data to develop an "early warning system" for educators: A proof of concept. *Computers & Education*, 54(2), 588-599.
- Mazur, J., & Lio, C. (2004). Learner Articulation in an Immersive Visualization Environment. Paper presented at the Conference on Human Factors in Computing Systems, Vienna, Austria.
- NetLogo. (2010). NetLogo. 2010, from <http://ccl.northwestern.edu/netlogo/>
- Poole, M. S., & Holmes, M. E. (1995). Decision Development in Computer/Assisted Group Decision Making. *Human Communication Research*, 22(1), 90-127.
- Rabiner, L. (1989). A tutorial on hidden markov models and selected application in speech recognition. Paper presented at the IEEE.
- Sengupta, P., & Wilensky, U. (2005). NetLogo Electrostatics model. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
- Stieff, M., & Wilensky, U. (2003). Connected chemistry - Incorporating interactive simulations into the chemistry classroom. *Journal of Science Education and Technology*, 12(5), 285-302.
- Strijbos, J.-W., & Fischer, F. (2007). Methodological challenges for collaborative learning research. *Learning and Instruction*, 17(4), 389-393.
- Thompson, K., & Reimann, P. (2010). Patterns of use of an agent-based model and a system dynamics model: The application of patterns of use and the impacts on learning outcomes. *Computers and Education*, 54(2), 392-403.

Acknowledgements

Case Study 3 is based on the pilot study for the Australian Research Council grant LP100100594. Lina Markauskaite acknowledges the contributions of the other chief investigators, Michael Jacobson and Chun Hu.

Social Skills as Predictors of Satisfaction and Performance in a Project-based Learning CSCL Environment: An Empirical Study

Michele Notari, Adrian Baumgartner, PHBern, University of Teacher Education, Gertrud-Woker-Strasse 5, CH-3012 Bern, Switzerland

Email: michele.notari@phbern.ch, adrian.baumgartner@phbern.ch

Abstract: The study looks for empirical answers to the following question: To what degree are self-rated individual social skills and the distribution of social skills within learning groups predictive for group member's satisfaction with performance and quality of collaboration? Data collection took place in a project-based learning curriculum of pre-service teachers. Two questionnaires were used, one at the beginning and one at the end of the learning cycle which lasted one semester. The investigation of 60 learning groups ($N = 155$) revealed the following results: Self-rated social skills are for the most part non-significant predictors for the satisfaction with group performance and the quality of collaboration. A different picture emerged on the group level: Members from groups which show a high and/or amongst themselves homogeneous distribution of specific social skills (e.g. exchange orientation, leadership) are more satisfied and collaborated better than groups with a high and heterogeneous distribution of skills.

Introduction

Common sense dictates that social skills are relevant ingredients for successful collaborative learning. However, hardly any studies can be found that tried to identify empirically and systematically the social skills most predictive of group performance (van Gennip, Segers, Tillema 2009) and collaboration. Furthermore, those few studies have relied almost exclusively on individuals, neglecting that group success and collaboration is as much dependent on individual skills as on the skill configuration within the whole group. In our own study, we have chosen a project-based (PBL) learning curriculum as a context to analyze collaborative learning processes. It is expected that students practice and refine these skills during the collaboration process (Peterson, 1997). In the project, lasting for three months, students collaborated in self-organized face to face meetings but also used computer-mediated communication channels like email, chat or voice over IP.

Social Skills in PBL

We use the term 'skill' to refer to the ability to perform a certain class of behavior (e.g. the behavior 'being able to organize things' as an expression of leadership skill). Following Rubin et al. (1995) and Rose-Krasnor (1997) a person has a high level of social skills when she acts effectively in social interactions. That means one is able to satisfy one's own goals and personal needs while maintaining positive relationships with others in specific contexts. As such, this definition does not tell us which social skills lead to an effective coordination of needs in a particular social setting, for example in collaborative project-based learning.

Peterson (1997) for example names five interpersonal skills particularly relevant for collaborative learning: consensus capacity, discussion skills, skills concerning evaluation and feedback formulation, conflict resolution skills and leadership ability. Heuermann and Krützkamp (2003) mention the importance of empathy, team building and sustaining skills, the capacity to formulate feedback, to mediate conflicts and to argue about common group goals and norms. At the moment, the suggestions of Petersons (1997) and Heuermann et al. (2003) remain prescriptive and empirically untested.

Empirical Approach / Method

The present study was conducted with 155 pre-service teachers in two cohorts (2009 and 2010) at the Pädagogische Hochschule Bern (University of Teacher Education). The students participated in a mandatory media education course and as a course requirement had to work on a media project during three months. They were free to select their group mates. Group size was two to three students.

Research Design

Research questions:

1. Which individual social skills are associated with group process variables (i.e. satisfaction with performance and quality of collaboration) in a collaborative project-based learning setting?
2. What configurations of social skills within learning groups (i.e. heterogeneous vs. homogeneous distribution and low vs. high expression of a skill) are associated with differences in group process variables?

At the start of the PBL curriculum teacher students (92 female, 63 male, average age: 24.27; SD = 3.48) completed a questionnaire (t1) self-assessing various social skills. The skills were alike to the interpersonal skills proposed by Peterson (1997) and Heuermann and Krützkamp (2003). At the end of the project, students were given a second questionnaire (t2) tapping their satisfaction with the progress of the project and their judgement about the quality of collaboration (process variables). No differences concerning the response behavior of the two cohorts (2009 and 2010) could be detected: t -test; $-1.3 < t < 1.0$; $133 < df < 144$; $0.19 < p$ (two sided) $< .991$

Self-assessment of Individual Social Skills (t1)

The questionnaire based on several standardized instruments by Gresham & Elliott, (1990, Social Skill Rating System), Walker & McConnell, (1988, Walker-McConnell Scale of Social Competence), Ladd & Profilet, (1996, Child Behavior Scale) and Vitaro, Glagnon, Piche et al., (1992) contained 16 self-referential statements which students rated on a four-point scale (totally agree – do not agree at all). The 16 statements were reduced to five factors using principal component analysis.

Group Process Variables (t2)

Students rated six process variables (i.e. satisfaction with performance, efficiency of collaboration, clear division of responsibilities, centrality of leadership, mutual support, group harmony and ability to bring in one's ideas) on a four-point scale (totally agree – do not agree at all). The items were formulated specifically for this research.

Analyses

In our research design individuals are nested within learning groups. As we were interested in the predictive power of individual (level 1) and group (level 2) level variables on satisfaction and quality of collaboration, a multilevel analysis approach was pursued using the hierarchical linear modelling software HLM 6.02 (Raudenbush, Bryk & Congdon, 2004). This was done for all outcome variables for which the intraclass correlation coefficient (ICC) demonstrated significant variance on level 2. Two outcome variables with non-significant ICCs (i.e. group harmony and ability to bring in one's ideas) were analysed with linear regression models. The basic regression equations were as follows:

$$\begin{aligned} \text{level 1: outcome} &= \beta_0 + \beta_1 (\text{individual social skill}) + r \\ \text{level 2: } \beta_0 &= \gamma_{00} + \gamma_{01} (\text{mean social skill}) + \gamma_{02} (\text{SD social skill}) + \gamma_{03} (\text{interaction mean x SD}) + u_0 \\ \beta_1 &= \gamma_{10} + u_1 \end{aligned}$$

The distribution of a specific social skill within learning groups was modelled on level 2 using group members average skill level (mean), variability of skill level within groups (SD) and the interaction between mean and variability.

Results

In order to reduce complexity the 16 items of the questionnaire (t1) were reduced to five factors using principal component analysis (equamax rotation). The five extracted factors explained 66.9% of the variance. Items were assigned to factors when their factor loadings were above .40.. All factor scales had satisfactory internal consistency (Cronbach's Alpha).

- **Exchange orientation:** e.g. getting along with other people, being able to collaborate, being able to compromise, being able to mediate in conflict situations (Cronbach's Alpha = .685).
- **Prosocial behavior/empathy:** e.g. openness to other people's opinions, being able to take someone else's perspective, being ready to help someone (Cronbach's Alpha = .600).
- **Social initiative:** e.g. initiating conversations, being able to make contact with other people easily (Cronbach's Alpha = .705).
- **Leadership:** e.g. being able to organize things, being good at taking on the leadership role (Cronbach's Alpha = .627).
- **Assertiveness:** e.g. setting clear limits to inappropriate demands, standing up for one's rights, feeling self-confident (Cronbach's Alpha = .652).

Of the five social skills (level 1) only two were predictive of the outcome of specific group process variables, i.e. students high in leadership skills regarded their group interactions as less mutually supportive (Beta = -.18, $p = .065$) and students high in assertiveness thought they had been less capable of bringing their ideas into the project (B = -.31, $p = .009$).

Configuration of Social Skills within a Group as Predictors of Satisfaction and Quality of Collaboration (Level 2)

Effects for Exchange Orientation

Members from groups in which the individual exchange orientation was high on average (mean) and at the same time homogeneously distributed (SD) reported more efficient collaboration (interaction mean x SD, $B = -2.77, p = .048$; see Figure 1) and a clearer division of responsibility (interaction mean x SD, $B = -2.32, p = .061$) than other groups. No effects could be found with respect to satisfaction with group work, centralized leadership, group harmony, mutual support and bringing in one's ideas.

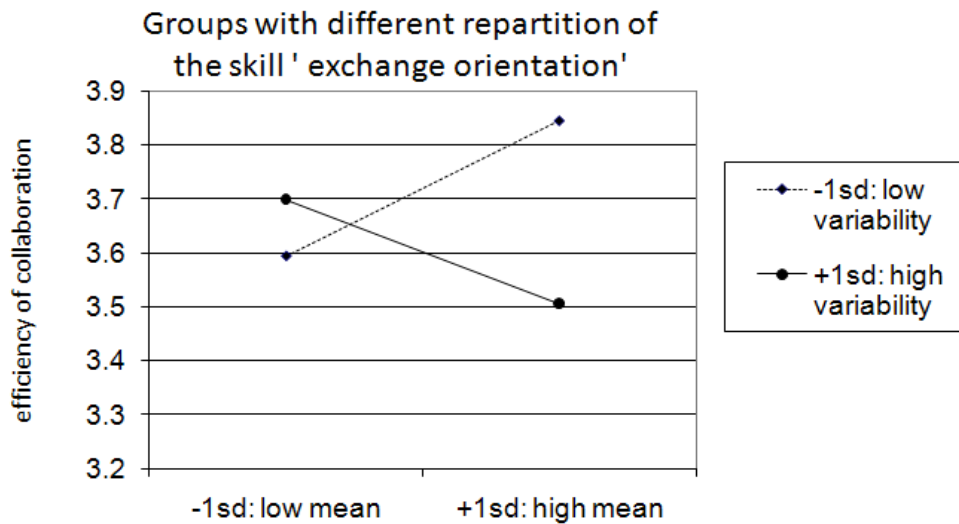


Figure 1. Interaction effect between average exchange orientation (mean) and variability of exchange orientation within groups on the perceived efficiency of collaboration.

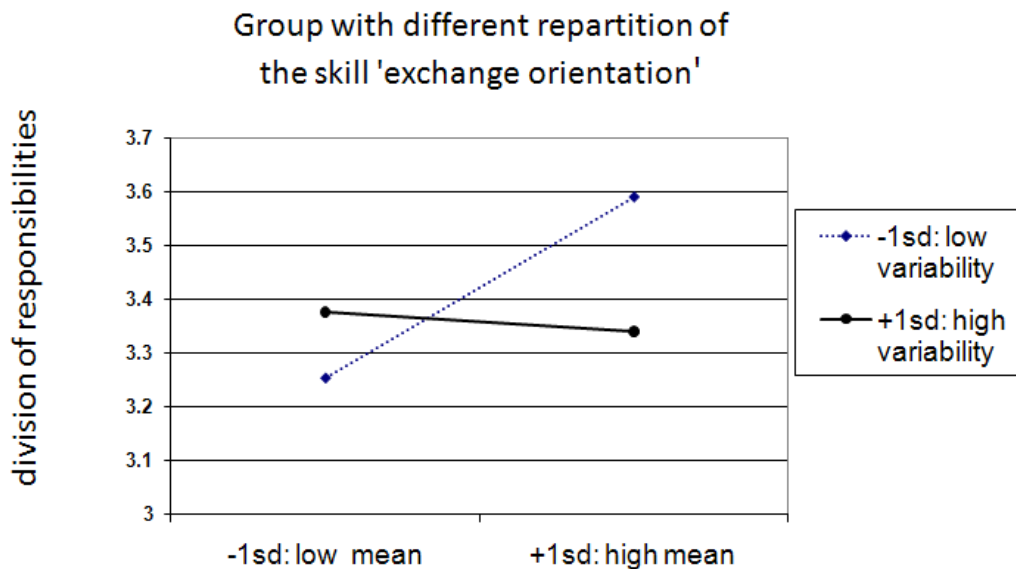


Figure 2. Interaction effect between average exchange orientation (mean) and variability of exchange orientation within groups on the division of responsibilities

Effects for Prosocial Behavior / Empathy

Group members satisfaction with performance (interaction mean x SD, $B = -2.04, p = .098$) and with the efficiency of collaboration (interaction mean x SD, $B = -2.02, p = .033$) is lower when prosocial behavior within the group is high but heterogeneously distributed. The same groups show a clearer division of responsibility (interaction mean x SD, $B = -2.86, p = .030$). In addition, in groups with a homogeneous distribution of prosocial behavior members more often stated to have had a centralized leadership, i.e. someone who was in

charge (main effect SD, $B = -1.03, p = .068$). No effects could be found with respect to mutual support, group harmony and bringing in one's ideas.

Effects for Leadership

Members from groups that were on average high in leadership skills reported more efficient collaboration (main effect mean, $B = .55, p = .008$) and a clearer division of responsibility (main effect mean, $B = .35, p = .090$). Furthermore, groups with a heterogeneous distribution of leadership skills more often had a centralized leadership (main effect SD, $B = .85, p = .007$). No effects could be found with respect to mutual support, group harmony and bringing in one's ideas.

Effects for Assertiveness

Bringing in one's ideas into the project is perceived to be easier when the average assertiveness in the group is high (Beta = .23, $p = .066$) or when heterogeneity of assertiveness within the group is low (Beta = -.20, $p = .026$). No effects could be found with respect to satisfaction with group work, efficiency of collaboration, division of responsibility, mutual support and group harmony.

Conclusion

Individual Social Skills as Predictors for Satisfaction and Quality of Collaboration

On the individual level, only two social skill variables served as predictors for group process variables.

Students high in leadership skills tended to be unhappy with the mutual support given within the group. Arguably, as leaders, they are responsible for many important decisions and maybe also in charge of the most difficult tasks. This may contribute to a feeling of isolation and lack of support.

Students high in assertiveness found it hard to bring their ideas into the project. However, when all group members are assertive (i.e. the skill level in the group is high and homogeneous) contributing ideas becomes easier. Assertiveness (operationalized here as self-confidence and standing up for one's rights) might be misunderstood as egoistical tendencies by less assertive people which in turn could lead them to selectively ignore contributions made by assertive group members.

In sum, the finding of only two significant individual level predictors demonstrates that the social skill distribution within a project group is more important for satisfaction with performance and quality of collaboration than a person's individual skills. This is further evidence for the context-dependency of social skills (Rose-Krasnor, 1997), i.e. whether a specific social skill is positive for collaboration in project-based learning depends on the group one is placed in and on the social skills levels of one's group members. Future studies should take this into consideration.

Configuration of Social Skills within a Group

Groups with a high and homogeneous exchange orientation (i.e. groups where members are cooperative, able to solve conflict, compromising and sociable etc.) collaborated more efficiently and divided responsibilities more clearly among group members. Following Dillenbourg and Jermann (2007) splitting tasks is detrimental to group learning as building a shared understanding is considered essential. On the face of it, therefore, it could be concluded that our groups with a high and even distribution of exchange orientation learn less than other groups. We think that such a conclusion would be premature. Division of responsibilities is conducive to the emergence of specific roles (not only leadership) which according to Strijbos (2007) lead to a higher degree of self-reported group efficiency. Following Tolmie et.al. (2010) the social benefits of collaborative learning are a separate outcome of group work, rather than being either a pre-condition for or a direct consequence of successful activity.

Groups which displayed a high and heterogeneous level of prosocial behaviour/empathy were reportedly collaborating less efficiently, divided responsibilities more clearly and were less satisfied with their performance. We assume heterogeneity to be the main factor responsible for these problems. For prosocial behavior reciprocity (or expressed in our group level terminology, homogeneity) is very important. Against the background of a lack of reciprocity, prosocial group members may decide to split tasks more often. Finally, groups with a high level of leadership collaborated more efficiently and divided responsibilities more clearly among its members. As could be expected, groups in which leadership skills are heterogeneously distributed, more often had a central leadership figure.

To sum up, high average levels of leadership skills and of exchange orientation within the group seem to be most beneficial to collaboration quality and satisfaction with performance.

References

- Dillenbourg, P., & Jermann, P. (2007). Designing integrative scripts. In F. Fischer, I. Kollar, & H. Mandl (Eds). *Scripting computer supported collaborative learning. Cognitive, computational and educational perspectives. Volume 6 (IV)* (pp. 275-305). Springer, New York .
- Gennip, N. A.E. van, Segers, M. S. R., and Tillema, H.H.. (2009). Peer assessment for learning from a social perspective: The influence of interpersonal variables and structural features. *Educational Research Review* 4(1), 41-54. doi:10.1016/j.edurev.2008.11.002. <http://linkinghub.elsevier.com/retrieve/pii/S1747938X08000420> (1.17.11).
- Gresham, F. M., & Elliott, S. N. (1990). *The Social Skills rating system*. Circle Pines: American Guidance Services.
- Heuermann, A., & Krützkamp, M. (2003). *Selbst-, Methoden-, und Sozialkompetenz. Bausteine für die Sekundarstufe II*. Berlin: Cornelsen.
- Ladd, G. W., & Profilet, S. M. (1996). The Child Behavior Scale: A teacher-report measure of young children's aggressive, withdrawn, and prosocial behaviors. *Developmental Psychology*, 32, 1008 -1024.
- Peterson, M. (1997). *Skills to enhance problem-based learning*. <http://www.med-ed-online.org/f0000009.htm> (01.17.2011).
- Raudenbush, S.W., Bryk, A.S, & Congdon, R. (2004). *HLM 6 for Windows* [Computer software]. Lincolnwood, IL: Scientific Software International, Inc.
- Rose-Krasnor, L. (1997). The nature of social competence: A theoretical review. *Social Development*, 6, 111 – 135.
- Rubin, K.H., Booth, C., Rose-Krasnor, L., & Mills, R.S.L. (1995). Social relationships and social skills: A conceptual and empirical analysis. In S. Shulman (Ed.), *Close relationships and socioemotional development*. (Vol. 7, pp. 63 - 94). Westport, CT: Ablex Publishing.
- Strijbos, J., Martnes, R. L., Jochens, W. M.G., Broers, N. J. (2007). The effect of functional roles on perceived group efficiency during computer-supported collaborative learning: a matter of triangulation. *Computers in Human Behavior*, 23(1), 353-380.
- Tolmie, A. K., Topping, K. J., Christie, D., Donaldson, C., Howe, C., Jessiman, E., Livingston, K. and Thurston, A. (2010). Social effects of collaborative learning in primary schools. *Learning and Instruction* 20(3), 177-191. doi:10.1016/j.learninstruc.2009.01.005. <http://linkinghub.elsevier.com/retrieve/pii/S0959475209000061> (01.17.2011).
- Walker, H. M., & McConnell, S. R. (1988). *Walker-McConnell Scale of Social Competence and School Adjustment*. Austin, TX: Pro-Ed.

Seven Challenges in CSCL

Ravi K. Vatrappu, Computational Social Science Laboratory (CSSL), Center for Applied ICT,
Copenhagen Business School, Denmark, vatrappu@cbs.dk

Abstract: This paper identifies and discusses seven challenges in the current state-of-the-art in Computer Supported Collaborative Learning (CSCL): (1) tensions between the dominant theoretical approaches and the lack of “native” theories, (2) development of CSCL systems that are pedagogically innovative as well as aesthetically pleasant, (3) designing collaborative learning interventions, (4) diffusion, adoption, and acceptance of CSCL technologies, (5) lack of comparative studies, (6) the gulf of relevance between CSCL research and practice, and (7) the gulf of rigor between CSCL insights and policy prescriptions.

Introduction

The purpose of this paper is to identify and discuss critical contemporary challenges in CSCL. The paper has two objectives. First, to collect and crystalize several diverse and disparate strands of on-going discussions within CSCL on theories, methods, technologies and so on. Second and last, to facilitate an artifact-centered debate and discussion of the key challenges identified to further both the intellectual rigor and societal relevance of CSCL studies and findings. The seven challenges are: (1) tensions between the dominant theoretical approaches and the lack of “native” theories, (2) development of CSCL systems that are pedagogically innovative as well as aesthetically pleasant, (3) designing collaborative learning interventions, (4) diffusion, adoption, and acceptance of CSCL technologies, (5) lack of comparative studies, (6) the gulf of relevance between CSCL research and practice, and (7) the gulf of rigor between CSCL insights and policy prescriptions. The remainder of the paper is organized as follows. In the next seven sections, each of these seven challenges are first presented and then discussed. Limitations of the paper are discussed towards the end.

Challenge #1: Resolving Theoretical Tensions: “Native Theories”

According to Suthers (2006), CSCL predominantly employs an intersubjective epistemology. As argued by Koschmann (2002), CSCL is centrally concerned with designing artifacts for and understanding practices of joint meaning-making in learning contexts. Theoretical approaches in CSCL are from a variety of disciplines and span socio-cognitive, socio-cultural, micro-sociological and structuralist paradigms. The nature of explanations range from demonstrating the pedagogical effectiveness of a technological design artifact, to improving collaborative learning outcomes by dialogue systems, and to uncovering interactional accomplishments in CSCL settings.

Currently, there is heavy theoretical borrowing in CSCL from reference disciplines such as developmental psychology (e.g., Piaget, Vygotsky) and sociology (Marxist dialectical materialism, Garfinkel’s ethnomethodology). That is, theories from reference disciplines are transported, translated and transplanted into CSCL. This creates a sense of theoretical diversity for the CSCL field as a whole and a sensibility of theoretical coherence for an individual research project. However, key theoretical concepts undergo “conceptual stretching” (Collier & Mahon Jr, 1993; Sartori, 1970) when decontextualized from the analytical contexts of reference disciplines. A prime example of this is the adoption of the notion of “affordance” from ecological psychology. The term was coined by J.J. Gibson (1979) and introduced to human-computer interaction by Norman (1990). Subsequent uptake in CSCL (Bonderup Dohn, 2009; Kreijns & Kirschner, 2001; Suthers, 2006) has paid little attention to the theoretical developments beyond Gibson’s seminal contribution and Norman’s original adaptation (cf. Vatrappu, 2010). As such, affordances by and large are understood to be features, widgets and tools instead of relational properties. Additionally, there exist unresolved tensions even in a seemingly coherent approach such as the socio-cultural tradition between process realism and inseparability of the individual and the social formation (Sawyer, 2002).

Issues in and aspects of CSCL crisscross the *psychological* (cognitive, cultural, ecological, cultural), *sociological* (micro, macro), *technological* (design, development, deployment, adoption, evaluation), *interactional* (appropriation, enactment), and *pedagogical* (knowledge, skills, aptitudes, outcomes). As such, CSCL needs a “theoretical object” that can help researchers develop a descriptive vocabulary and an interpretive framework for CSCL phenomena. To address this challenge, “native” theories are needed. Native theories are first-order theories that conceptualize, describe, analyze, interpret, explain (and possibly predict) phenomena in CSCL with regard to intertwining of collaborative actors, technological artifacts, joint meaning-making practices, pedagogical processes and products. Notable attempts include but are not limited to group cognition (Stahl, 2006), theory of socio-technical interactions (Vatrappu, 2009), and learning as participation in autotactokinetic systems (Barab et al., 1999). We need more empirically informed first-order native theories and “native” theory-informed empirical studies to advance the field of CSCL.

Challenge #2: Systems Development: “Broccoli vs. Ice-cream”

The second challenge refers broadly to the role of computational support in CSCL systems. From a HCI standpoint, usability, sociability and learnability are three interdependent design dimensions for CSCL systems (Vatrapu, Suthers, & Medina, 2008). Given the central role that motivation plays in learning (Cordova & Lepper, 1996; Eales, Hall, & Bannon, 2002), it is critical that CSCL systems go beyond being functional research prototypes and become professional-grade applications that provide rich and engaging user experiences from an aesthetic, social phenomenological and critical design perspectives. In addition to traditional CSCL technology design concerns of enhancing learning, improving group awareness and such, the design challenge is to incorporate hedonic usability (Hassenzahl, 2004). One consequence of not adopting a holistic design approach might be the prevalence of “performance vs. preference paradox” (Vatrapu, et al., 2008). The “preference vs. performance paradox” points to the fact that high levels of user performance with and/or technical performance of a system can in some instances be accompanied by low user satisfaction scores. If CSCL systems design only incorporate instrumental aspects and but not the hedonic aspects of design, there might be high performance gains on short-term studies (in lab settings or in-situ DBR settings) but negative preference attitudes and low long-term adoption of CSCL systems. To put it differently, there is the danger of the “broccoli vs. ice-cream effect” with instrumentally rich but experientially poor CSCL systems. Just because the new generations of learners are increasingly growing up with pervasive and ubiquitous information and communication technologies (ICTs), it doesn’t mean that they will automatically and universally prefer CSCL systems. One of the prime arguments for technology enhanced learning has been that in a world of constant connectivity and near ubiquity of ICTs, technologies must be leveraged pedagogically. But the HCI design challenge here is that the ICTs that students are immersed in and engaged with in their daily lives outside the formal learning settings are aesthetically rich, multi-textured and for a lack of better words, *cool and sweet* (like ice-cream). This is in contrast to the current situation, where many and not all, CSCL systems are functionalistic but not aesthetically rich from a user experience perspective and as such might be perceived as dull, boring, and uncool (like broccoli). That is, just because students are growing up with digital technologies; it doesn’t necessarily follow that they will like *learning* technologies (just like their love for eating ice-cream doesn’t guarantee a concomitant love for eating broccoli).

Challenge #3: Orchestrating Collaborative Learning: Re-centering Teachers

Given CSCL’s foundational emphasis on shared conception of the problem and joint meaning-making, orchestrating collaborative learning is a core issue. As an instructional technology paradigm, CSCL displaces the teacher from the core of the learning activity and instead locates the center with the collaborative group with near-symmetrical socio-cognitive configurations, equitable division of labor, shared conception of the problem, and distributed task goals. Scripting has been an influential, productive and effective strategy to orchestrate collaborative learning (Weinberger, Ertl, Fischer, & Mandl, 2005). Scripting has been supported from both Vygotsky’s (1930/1980, 1962) concept of the “Zone of Proximal Development” as well as Bruner’s (1978) concept of “Scaffolding”. However, as pointed by many researchers, the notion of “Zone of Proximal Development” is an asymmetrical social configuration between a more capable adult-teacher and the child-student (Fernandez, Wegerif, Mercer, & Rojas-Drummond, 2002; Garrison, Anderson, & Archer, 2000). Near-symmetrical socio-cognitive configurations of collaborative groups are therefore a conceptual challenge within CSCL. Orchestrating CSCL by re-centering teachers within the classroom practice could be a step towards addressing this challenge.

Challenge #4: Diffusion, Adoption and Acceptance of CSCL Technologies

With respect to existing work in CSCL, we can make these characterizations. First, most, if not all, of CSCL research is focused on the primary and secondary school settings with relatively fewer higher education applications (e.g., Strijbos, Kirschner, & Martens, 2004). Second, a majority of CSCL research is in the STEM disciplines (Science, Technology, Engineering, and Math). Third and last, there is little cross-fertilization of ideas between related fields of in human-computer interaction (HCI), computer supported cooperative work (CSCW), designing interactive systems (DIS) and CSCL. While there has been considerable systems development research in CSCL (for example, see the argumentation systems reviewed by Scheuer, Loll, Pinkwart, & McLaren, 2010), there is little attention paid to the diffusion (Rogers, 1995), adoption (Katz & Shapiro, 1986) and acceptance (Venkatesh, Morris, & Davis, 2003) of CSCL technologies. In my opinion, CSCL faces diffusion, adoption and acceptance challenges both horizontally (across the STEM disciplines and with other academic fields such as HCI and CSCW) and vertically (from secondary to tertiary education). At present, CSCL is relatively poor at diffusing ideas and tools to related fields such as organizational learning.

Challenge #5: Comparative Studies

Given that culture, language, cognition, and action are intricately intertwined (Vatrapu, 2010), in a technology driven multi-cultural and multi-lingual world, we need to empirically examine the design assumptions in CSCL. Learning sciences researchers have begun to critically engage with these issues by employing a rich mix of theories and methods across a diverse range of informal and formal learning settings (Rose et al., 2010). For instance, emerging results in CSCL empirically document cross-cultural variation in tool appropriation and social relationships in CSCL systems (Vatrapu, 2008; Weinberger & Nistor, 2010). One productive avenue for CSCL could be to employ the comparative method to study phenomena across a wide variety of cultures, languages, contexts, countries and settings. "Multiple conjectural causation" is at the heart of the comparative method and posits a combinatorial relationship between causes and effects-multiple causes interact in different combinations to produce effects (Ragin, 1987).

Challenge #6: Practice Implications: Gulf of Relevance

The practice challenge in CSCL relates to bridging the gulf of relevance between CSCL research and teachers' professional practice in schools. Generating implications for the professional practice of teachers has long been a topic of interest within CSCL (e.g., Lockhorst, Admiraal, Pilot, & Veen, 2002; Lund & Baker, 1999; Resta, Christal, Ferneding, & Puthoff, 1999). As mentioned earlier, in CSCL, one side effect of the near-symmetrical socio-technical configurations of students, equitable division of labor, shared conception of the problem, and shared task goals is the displacement of the teacher from the analytical center and a delimitation of the teacher's role to that of a facilitator of discourse and a designer/architect of content. In order to bridge the gulf of relevance between research and practice, CSCL insights needs to be relevant across the broad spectrum of context-dependent, situation-specific, and institutionally-relative teaching practices. Both student-teacher and student-teacher interaction as well as "outeraction" (Nardi, Whittaker, & Bradner, 2000) need to be addressed. Further, CSCL research needs to address the challenges that teachers face in the context of the high-performance/high-density/date-rich 21st century classrooms with 1:1 computing, ubiquitous, pervasive, and mobile computing, diversified info information ecologies, and diverse learning trajectories of individual students (Crawford, Schlager, Penuel, & Toyama, 2008). As such, I think that CSCL research needs to focus on providing both computational and methodological support for teachers in *real-time* and *in-situ* classroom settings to bridge the gulf of relevance (see NEXT-TELL project website (www.next-tell.eu) for a description for the demands of teaching in the classrooms of the 21st century).

Challenge #7: Policy Prescriptions: Gulf of Rigor

Engagement with policy-makers is gaining increasing attention with CSCL (Vosniadou & Dirckinck-Holmfeld, 2009) and the wider learning science community in general (the recent ISLS members listserv discussion on policy). However, we need to recognize that (1) *policy-making/policy-formulating* and *policy-informing* are two different endeavors requiring different competencies and that (2) *educational-policy*, *pedagogical-policy*, and *learning-policy* are at different levels. *Policy-informing* requires translating and advocating the CSCL insights gained from systematic research into meaningful and actionable empirical facts for the perusal of decision-makers in the different communities of policy practice (from the classroom and the school to the school board and the national government). As such, *informing-policy* is a translation and advocacy task that requires policy-informers to have CSCL domain competencies, community credibility, and advocacy skills. In contrast, *policy-making/policy-formulating* requires and demands expertise beyond the CSCL disciplinary domain (such as public administration, educational policy, educational philosophy). With regard to the distinction between the different levels of *educational-policy*, *pedagogical-policy*, and *learning-policy*, a key policy challenge for CSCL is its conception of students and teachers. As mentioned earlier, CSCL as an instructional paradigm can decenter the teacher. Moreover, the collaborative learning setting itself needs to be critically examined for policy-informing implications. How should we reconcile the small-group oriented design and analysis of CSCL with the legally mandated assessment and certification of individual students rather than collaborative learning groups? Educational effectiveness and educational efficiency have long been the buzzwords in educational reform. However, as Ericson and Ellett (2002) argued, "students are as causally central as educators in bringing about higher educational achievement" (p.1). In order to consider *educational-policy* implications of CSCL, we need to situate students within the macro-sociological process (see Figure 1).

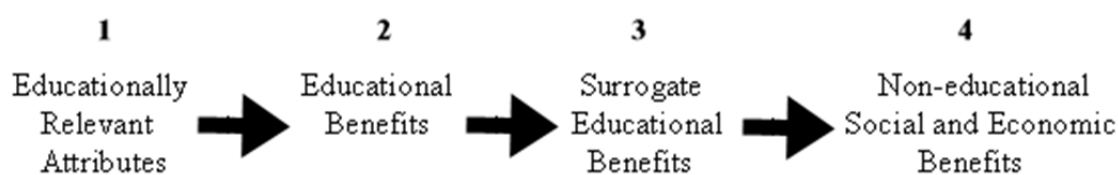


Figure 1. Macro-Sociological Process View of the Educational System (taken from Ericson & Ellett, 2002).

The “Surrogate Educational Benefits” [Figure 1, index 3] of certifications, diplomas, transcripts, grades and standardized testing scores function to position students in the market place of jobs and their associated benefits, perks along with the social status and wealth. Only “Educational Benefits” [Figure 1, index 2] and “Surrogate Educational Benefits” [Figure 1, index 3] of the schematic above are within the control of CSCL researchers and educators. The partial control over the macro-sociological process of education should be taken into account when thinking about educational-policy from a CSCL perspective. In order to inform educational-policy we need to recognize the centrality of student agency and in the noble enterprise of education. As Ericson and Ellett (2002) say:

Yet, as we shall argue, it is students—their goals, motivations, and conceptions of the good life—that may well prove to be the undoing of the educational reform movement. In other words, we might well improve the quality of teachers, legislate higher content and performance standards and academic requirements, and reform teacher education to the educational reform movement's content, and still totally fail in achieving anything close to educational excellence in our schools. (Ericson & Ellett, 2002)

Conclusion

The list of seven challenges is not exhaustive. Other CSCL researchers and practitioners may identify other challenges. The purpose of the paper is to jumpstart a discussion on the grand challenges in CSCL. No concrete solutions are offered and it might very be the case that some, if not all, of these challenges remain intractable and insurmountable. But an empirically informed discussion of CSCL challenges could provide opportunities to take stock of the accumulated body of knowledge and look into the future.

References

- Barab, S. A., Cherkes-Julkowski, M., Swenson, R., Garrett, S., Shaw, R., & Young, M. (1999). Principles of Self-Organization: Learning as Participation in Autocatakinetic Systems. *Journal of the Learning Sciences*, 8(3/4), 349-390.
- Bonderup Dohn, N. (2009). Affordances revisited: articulating a Merleau-Pontian view. *International Journal of Computer-Supported Collaborative Learning*, 4(2), 151-170.
- Bruner, J. (1978). The role of dialogue in language acquisition. In A. Sinclair, R. Jarvella & W. J. M. Levelt (Eds.), *The child's conception of language* (pp. 241-256).
- Collier, D., & Mahon Jr, J. (1993). Conceptual "stretching" revisited: Adapting categories in comparative analysis. *American Political Science Review*, 87(4), 845-855.
- Cordova, D., & Lepper, M. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology*, 88(4), 715-730.
- Crawford, V., Schlager, M., Penuel, W., & Toyama, Y. (2008). Supporting the art of teaching in a data-rich, high-performance learning environment. In E. B. Mandinach & M. Honey (Eds.), *Data-driven school improvement* (pp. 109–129). New York: Teachers College Press.
- Eales, R. T. J., Hall, T., & Bannon, L. J. (2002). *The motivation is the message: comparing CSCL in different settings*. Paper presented at the Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community.
- Ericson, D., & Ellett, F. (2002). The Question of the Student in Educational Reform. *Education Policy Analysis Archives*, 10(31), <http://olam.ed.asu.edu/epaa/v10n31/>.
- Fernandez, M., Wegerif, R., Mercer, N., & Rojas-Drummond, S. (2002). Re-conceptualizing "scaffolding" and the zone of proximal development in the context of symmetrical collaborative learning. *Journal of Classroom Interaction*, 36(2/1), 40-54.
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, 2(2-3), 87-105.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.
- Hassenzahl, M. (2004). The interplay of beauty, goodness, and usability in interactive products. *Human-Computer Interaction*, 19(4), 319-349.
- Katz, M., & Shapiro, C. (1986). Technology adoption in the presence of network externalities. *The Journal of Political Economy*, 94(4), 822-841.
- Koschmann, T. (2002). Dewey's contribution to the foundations of CSCL research. *Computer Support for Collaborative Learning (CSCL 2002)*, Boulder, CO.
- Kreijns, K., & Kirschner, P. (2001). *The social affordances of computer-supported collaborative learning environments*. Paper presented at the 31st Annual Frontiers in Education Conference, Reno, USA.
- Lockhorst, D., Admiraal, W., Pilot, A., & Veen, W. (2002). Design Elements for a CSCL Environment in a Teacher Training Programme. *Education and Information Technologies*, 7(4), 377-384.

- Lund, K., & Baker, M. (1999). Teachers' collaborative interpretations of students' computer-mediated collaborative problem-solving interactions. In S. P. Lajoie & M. Vivet (Eds.), *Proceedings of the International Conference on Artificial Intelligence and Education, Le Mans, July 1999. Artificial Intelligence in Education* (pp. 147-154). Amsterdam: IOS Press.
- Nardi, B., Whittaker, S., & Bradner, E. (2000). Interaction and outercation: instant messaging in action. *Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW 2000)*, 79-88.
- Norman, D. (1990). *The design of everyday things*. New York: Doubleday.
- Penuel, W., Roschelle, J., & Abrahamson, L. (2006). Research on classroom networks for whole-class activities. *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education, Los Alamitos, CA, IEEE*, 222-229.
- Ragin, C. (1987). *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*: University of California Press.
- Resta, P., Christal, M., Ferneding, K., & Puthoff, A. K. (1999). CSCL as a catalyst for changing teacher practice. *Proceedings of the 1999 conference on Computer support for collaborative learning*, 60.
- Rogers, E. (1995). *Diffusion of innovations*: Free Press.
- Rose, C. P., Kam, M., Laferriere, T., Law, N., Moraveji, N., & Vatrappu, R. (2010). Internationalizing the learning sciences from formal to informal learning environments. *Symposium. Proceedings of the 9th International Conference of the Learning Sciences - Volume 2*, 102-103.
- Sartori, G. (1970). Concept misformation in comparative politics. *The American Political Science Review*, 64(4), 1033-1053.
- Sawyer, R. K. (2002). Unresolved Tensions in Sociocultural Theory: Analogies with Contemporary Sociological Debates. *Culture & Psychology*, 8(3), 283-305.
- Scheuer, O., Loll, F., Pinkwart, N., & McLaren, B. (2010). Computer-supported argumentation: A review of the state of the art. *International Journal of Computer-Supported Collaborative Learning*, 5(1), 43-102.
- Stahl, G. (2006). *Group Cognition: Computer Support for Building Collaborative Knowledge*: MIT Press.
- Strijbos, J., Kirschner, P., & Martens, R. (2004). *What we know about CSCL and implementing it in higher education*: Springer.
- Suthers, D. (2006). Technology affordances for intersubjective meaning-making: A research agenda for CSCL. *International Journal of Computers Supported Collaborative Learning*, 1(3), 315-337.
- Vatrappu, R. (2008). Cultural Considerations in Computer Supported Collaborative Learning. *Research and Practice in Technology Enhanced Learning*, 3(2), 159-201.
- Vatrappu, R. (2009). Toward a Theory of Socio-Technical Interactions in Technology Enhanced Learning Environments. In U. Cress, V. Dimitrova & M. Specht (Eds.), *EC-TEL 2009, Lecture Notes in Computer Science (LNCS) 5794* (pp. 694-699). Berlin Heidelberg Springer-Verlag.
- Vatrappu, R. (2010). Explaining Culture: An Outline of a Theory of Socio-Technical Interactions. *Proceedings of the 3rd International Conference on Intercultural Collaboration (ICIC 2010)*, 111-120.
- Vatrappu, R., Suthers, D., & Medina, R. (2008). Usability, Sociability, and Learnability: A CSCL Design Evaluation Framework. *Proceedings of the 16th International Conference on Computers in Education (ICCE 2008)*, (CD-ROM).
- Venkatesh, V., Morris, M., & Davis, F. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly*, 27(3), 425-478.
- Vosniadou, S., & Dirckinck-Holmfeld, L. (2009). CSCL and the transformation of education. *Proceedings of the 9th international conference on Computer supported collaborative learning - Volume 2*, 279-279.
- Vygotsky, L. (1930/1980). *Mind in society*: Harvard University Press.
- Vygotsky, L. (1962). *Thought and Language*. Cambridge: Massachusetts Institute of Technology.
- Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer-supported collaborative learning. *Instructional Science*, 33(1), 1-30.
- Weinberger, A., & Nistor, N. (2010). Culture, profession, and attitudes towards educational technology: a large-scale, german-romanian study. *Proceedings of the 3rd international conference on Intercultural collaboration*, 199-202.

Acknowledgments

Sincere thanks to the four anonymous reviewers for their critical comments on the original full-paper submission. This work was partially supported by the NEXT-TELL - Next Generation Teaching, Education and Learning for Life integrated project co-funded by the European Union under the ICT theme of the 7th Framework Programme for R&D (FP7) and the Comparative Informatics Workshop grant from Danish Ministry of Science, Technology and Innovation under the Second International Network Programme. Any opinions, findings, interpretations, conclusions or recommendations expressed in this paper are those of its author and do not represent the views of the European Commission and/or the Danish Ministry of Science, Technology and Innovation.

Retelling Stories: Setting Learner Narratives in Resource Ecologies

Joshua Underwood, Rosemary Luckin, Niall Winters, London Knowledge Lab, Institute of Education,
University of London, 23-29 Emerald Street, London WC1N 3QS, United Kingdom
Email: junderwood@ioe.ac.uk, r.luckin@ioe.ac.uk, n.winters@ioe.ac.uk

Abstract: We explore the use of learner narratives and narrative methods in the design of CSCL. Our data are accounts of self-initiated foreign language learning. These stories describe the learning of new vocabulary from the learner's perspective, revealing key interactions with language, people and various other resources in linked episodes that take place across various settings. Such narratives provide valuable insights into processes that are difficult to observe. We introduce a new technique to document interactions described in these learner narratives within ecologies of resources (Luckin, 2010) and provide detailed analysis of a single story in order to illustrate the use of this technique and show how it informs design.

Introduction: Taking Learners' Stories Seriously

Kukulka-Hulme (2007) notes, "ethical and practical issues get in the way of analysing" the "fragmented conversations" (p. 30) learners have across distributed media, settings and times using different tools. This is partly because of the difficulties associated with observing such practices. Yet, learners themselves are often able to construct informative, compelling narratives describing this learning. In education research, while concerns about validity and generalisability remain, the value of learner narratives and narrative methods is accepted (Clandinin & Connelly, 2000). However, learners' narratives are not often used to inform CSCL design. Yukawa (2006) used narrative analysis to reveal and describe co-reflection in the learning experiences of two students in an online action research course. Kupperman and Weisserman (2000) also used narratives in analysis; they asked participants to construct narratives describing their experiences of playing online simulations and aimed to merge these accounts with their own observations and log data in a single polyvocal, descriptive and reflective narrative. Mor and Noss (2008) use narrative methods both in their analysis of learner activity and to guide CSCL design, emphasising the need to understand and design support for learners' own narrative construction. Even in the field of Narrative Interactive Learning Environments, systems that explicitly use narrative to support learning, Brna (2008) notes a lack of methods that incorporate narrative approaches. Brna goes on to suggest there is room for new methods that "take the stories of participants very seriously" (p.36). In this paper we aim to demonstrate one way we can take learners' stories seriously and make systematic use of them in the design of CSCL systems that aim to prompt and guide learners' narrative constructions.

Narrative Construction, Narrative Guidance & Learner Context

Previously, we have described narrative construction as the active process of meaning making through which learners discern and impose a structure on their learning experiences, making links and connections in a personally meaningful way (Underwood et al, 2006). In contrast, narrative guidance is provided by the "design elements that teachers and/or software need to provide in order to help learners interpret the resources and experiences they are offered" (Underwood et al, 2006, p.3). More recently, Luckin (2010) links learner context, narrative construction and narrative guidance; "Context is dynamic and associated with connections between people, things, locations and events in a narrative that is driven by people's intentionality and motivations. Technology can help to make these connections in an operational sense. People can help to make these connections have meaning for a learner" (p.18). Our aim is to design guidance for adult language learners in constructing narratives that lead to learning new vocabulary. We are interested in understanding how successful language learners acquire new vocabulary in order to design prompts for others to adopt similar practices. It is difficult to observe such learning, not least because it takes place at unpredictable times across various settings. Hence, one way we are informing our design is through analysis of the stories told by successful learners.

Method & Analysis: Setting Language Learners' Stories in Resource Ecologies

We interviewed fifteen long-term learners of various European languages. All participants had advanced competency in at least one foreign language, equivalent to level C1/C2 of the CEFR (1). Most had spent some months living in a culture speaking the foreign language. Participants' ages ranged between 25 and 60 with mean and median ages being late 30s. In semi-structured interviews participants talked about things they use to support their language learning and the constraints they encounter. Conversation then often turned naturally to descriptions of specific experiences. If this was not the case we prompted participants to recall and describe in some detail a recent vocabulary learning experience. Due to space restrictions, we present here a single story extracted from these interviews. Ines' (2) mother tongue is Spanish. We selected her story because it is representative and illustrates in a single account features we found across several other stories. Also, we

ourselves learnt something about the expression that is the object of Ines' inquiry (3). As with other stories, we first drafted our own summary of the story from interview transcripts and then asked Ines to comment on our telling of her story, to suggest any changes and to fill in some missing details.

Ines is in the pub with friends. The football is on the TV. She hears the commentator say something like "... he's at sixes and sevens". She's been living in Ireland for years now and her English is very good but she's never heard that expression before. Her interest is piqued. She more or less gets the meaning in this context but she wants to check and improve her understanding, so she makes a mental note to do so. A little later she asks a friend about the expression. He says it's not an expression he would use. Ines is not very confident with the explanation he gives. She moves her ring from her right hand to her left hand, a habit she has developed to help remind her to look things up. Later at home, she notices her ring and looks up the expression. At first she can't remember exactly what it was, something to do with six and seven. Eventually, she finds it in her dictionary: "at sixes and sevens - in a state of total confusion or disarray". She is now more confident she understands. However, Ines's story doesn't end there. She isn't sure whether she has used 'at sixes and sevens' in conversation. She feels doing so might require conscious effort or perhaps she just hasn't had the opportunity.

This story is derived from Ines's account, as told by her in interview (see Table 1) and later elaborated in email exchanges. Ines confirmed that this account is, for her, a good retelling of her story. However, the story told here includes information that was only inferred in the original telling and combines information that was distributed across interview and emails. Also we have transposed the story to the third person (she) and the present tense, positioning the reader as observer, reflecting the traditional research perspective. The story was told in the first person (I) and resonated with our own experiences of learning vocabulary, prompting us to think about how we have acted in similar situations, our own strategies for remembering and investigating such language, and the many times we have heard interesting 'new' words or expressions only to lose them in the hustle of other activity and passing time. Such resonance is one criteria for validity in narrative approaches and the way stories act to prompt us to reflect on our own experience is an illustration of the value of stories. We offer this story here in the hope that for some readers the story will have similar validity and value. Notwithstanding our belief in the value of individual readers' unmediated interpretations of such narratives, we now offer our own approach to interpreting these learner narratives and show how this can inform design.

Connelly and Clandinin (2000) suggest three dimensions of narrative should be explored simultaneously: *temporality*, *sociality* and *space*. *Temporality* guides us to look at a story as a process and consider it in the context of past, present and future. *Sociality* requires us to consider the impact of personal feelings, hopes desires and other aspects both of participants' and our own (researcher's) agency. *Sociality* also means to draw our attention to "the environment, surrounding factors and forces, people and otherwise, that form each individual's context" (Clandinin, Pushor & Murray Or, 2007, p.23). *Space* guides us to think through the impact of each physical setting on experience. To facilitate this kind of analysis we plot events and interactions with people, the environment and other resources from Ines's narrative in a chronologically ordered chart (see Figure 1). This builds on representations (e.g. CORDFU) successfully employed previously to represent dialogue and feature use within CSCL environments (Luckin, 2003). For mapping experiences in ubiquitous technology-rich environments, we need to look beyond interactions with traditional computing resources. Consequently, we expand the elements included on the y-axis to include all resources that may contribute to learner context. We organise these using the general categories suggested by Luckin (2010):

Context is a learner's dynamic lived experience of the world that is constructed through their interactions with multiple *concepts*, *people*, *artefacts* and *environments*. These interactions are *spatially and historically contingent* and are *driven by the goals and feelings* of those who participate. (Luckin, 2010, p.34 – *italics added*)

The learner's actions and the goals, feelings and other resources the learner brings to an interaction are critically important; we group references to these in a layer labelled *learner agency & resources* (see Figure 1). We organise other resources in layers labelled *knowledge & skills*, *environment*, *people* and *tools*. Between the learner and these resources we introduce a layer labelled *filters*; filters influence access to resources (Luckin, 2010). Vertical lines break the narrative into discrete episodes. Key events or actions within episodes are numbered sequentially; we describe the significance of connecting arrows later. Representing interactions with resources in this way helps us focus on the connections between episodes and on changes over time, e.g. where is this happening now, how has access to resources changed, what filters constrain interactions and how do these change, how has the learner changed? Our next step is to identify and label transitions in the story. Benford, Giannachi, Koleva and Rodden (2009) identify six kinds of transition in mixed reality experiences (Beginnings, Endings, Role transitions, Interface transitions, Traversals between physical and virtual worlds, Temporal transitions) and note that these require careful design and management; it is in transitions that there is greatest risk to coherence and continuity. By providing stronger narrative guidance at such points, we may hope to remediate this risk and support learners' narrative construction. Hence in analysing Ines's successful learning

narrative we aim to identify the events and resources that support her as she moves through such transitions. By doing so we hope to identify opportunities to prompt and support other learners' in creating similarly connected learning narratives. Further analysis aims to identify key features on which Ines' successful outcome depends.

Table 1: Extracts from interview transcripts and email exchanges indexed to events identified in Figure 1.

Interview		
1) Interviewer: "...how do you learn English..." 2) Ines: talking about using dictionaries "...so, I'll give you an example, so I heard..." This leads into the story as told below.		
Episode 1 1) "...the other day somebody saying something like, oh I was <i>at sixes and sevens</i> ..." 2) "...it was during a soccer match actually and we were in the pub and it came out of the commentators..." 3) "...I never heard this before..." 4) "So obviously because your in a conversation you have an idea of what is going on... from the context you can actually make out what the person is talking about..." 5) "I just said, oh my I haven't, I thought, wow... you know I wonder what it means" 6) "You know you kind of make a mental note, you say I must actually check this up as soon as I can"	Episode 2 1) "So the first thing I did, because it was bothering me so much, was I asked somebody, 2) and he said 'oh yeah, yeah I heard something like that but it is not an expression that I would use'..." 3) "I didn't understand exactly what he meant" 4) "what I do is... I wear my ring on my right hand so change it to my left hand, then I know there is something to check"	Episode 3 1) "I didn't remember exactly what it was, but I knew it had to do with the number six and the number seven" 2) "...at home I would actually physically get up and go into, you know my office where I have all the dictionaries and actually take the dictionary out and 3) check it up ..."

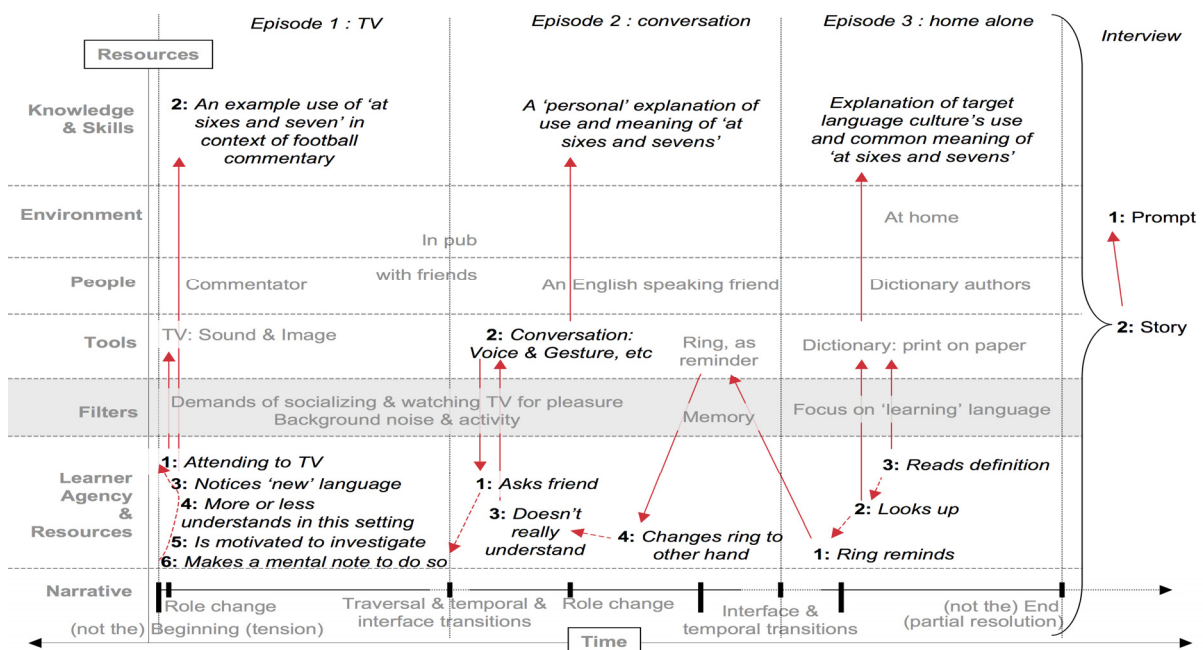


Figure 1. Chronologically Ordered Interactions with Resource Ecologies in Narratives (COIREN) Chart.

To help us identify and make explicit our interpretation of key features we adapt contingency graphs (Suthers, Dwyer, Medina, & Vatrapu, 2010); contingencies are ideally "manifest relationships between events" and events are "observed changes in the environment" (p.12). Contingency graphs express relationships between events. Given the nature of our data, we identify events described or implied by the narrative. Evidence for contingencies between these is implied by the narrative or self-evident. For example, Ines noticing the expression 'sixes and sevens' is dependent on the commentator using it; we represent this relationship with an arrow. So, how does Ines learn 'at sixes and sevens'? Our interpretation of events contributing to this learning is overlaid in Figure 1. Solid arrows connect contingencies between resources, including other people, and Ines; dotted arrows indicate contingencies between her own acts. We read the graph as follows, Ines's understanding of 'at sixes and sevens' is informed by her reading of the dictionary definition, her friend's explanation, and her recall and interpretation of the setting in which she heard it. These events are contingent on each other and other events, the filters and resources that create her context. Looking up the expression is contingent on availability

of a dictionary, her ability to use a dictionary and to relate the spoken form to its written form, and is filtered by the lack of other distracting activity. Remembering to look the word up is facilitated by her reminder strategy and the presence of her ring. The ring travels with her and helps bridge the temporal transition between episodes. Switching her ring is motivated by the realisation she doesn't really understand 'at sixes and sevens'. In part, this is caused by her conversation, which in turn is contingent on the presence of an English speaking friend, her decision to ask about 'sixes and sevens', her ability to communicate the expression, and her having noticed it in the first place. Of course any account of this type is incomplete; there will be critical events outside the story, e.g. developing the competence to notice the expression. Nevertheless, we find the identification of contingencies and transitions in this story useful in moving towards designing support for this kind of learning.

Discussion: Deriving Design Challenges, Limitations & Future Work

Our analysis describes a sequence of events and actions that we assert contribute significantly to the learning described by Ines' story. In designing from Ines' story, it is important to note that we do not seek to enhance the interactions in her story but rather to guide other learners' narrative construction of similar learning. In similar stories, similar events may or may not happen. If they don't happen they will affect the outcome of the story. For example, if learners do not notice new language they cannot decide to investigate it, if learners cannot remember the language they decide to investigate and/or don't have access to appropriate resources they can't look it up later. These represent opportunities for computer support for personal and collaborative learning and challenges for design: What can we do to prompt learners to notice new language? How can we support memory across episodes? How can we provide access to and make learners aware of appropriate resources at the right time and in the right place? We can look at each contingency identified in figure 1 and interpret it as a design challenge, asking ourselves how can we increase the chances of this happening. There is no space to work through each of these design challenges here but readers may wish to think these through for themselves.

Clearly, there are issues in deriving designs from a single learner's story. Ines' story is representative in that it exemplifies many features of a pattern common across other stories we were told. We call this personal and collaborative language inquiry. A learner notices new language and is personally motivated to investigate it. The learner forms a provisional hypothesis about meaning, which is iteratively refined and tested through inquiry employing various resources including people. Often, the stimulus for inquiry is encountered in one setting but, because of availability of resources and/or other filters affecting interaction, active inquiry is delayed to later episodes. Critical factors for success are learner motivation and memory, the ability to link and sustain inquiry across episodes and relate spoken and written forms, and availability of appropriate resources. Our initial design solution is a mobile multimedia vocabulary notebook providing 'one-click' access to a customisable collection of resources, including social media, for personal and collaborative inquiry (Underwood, Luckin, Winters, 2011). The interface provides static narrative guidance by: supporting quick capture and revisiting of stimuli for inquiry, prompting users to reflect on understanding, keeping an inspectable history of changes, providing easy access to resources that support inquiry and options for sharing inquiries.

In future work we aim to scaffold learner activity by providing adaptive narrative guidance. Scaffolding 'involves the evaluation of learner need, the provision of assistance and the withdrawal of that assistance in order to engender learner development' (Luckin, 2010). Van Lier (2007) suggests scaffolding often focuses attention on support giving strategies and the agency of collaborators. He points out the need not to lose sight of the learner's agency. Ultimately, it is how the learner interprets situations and acts that is critical. Learner narratives are useful because they reveal such agency. In Ines's story it is her who takes the initiative, deciding what she wants to learn, it is Ines who identifies resources and collaborators that can help her and it is Ines who decides whether she needs more help and when and where to access this. To scaffold learners towards adopting similar successful self-directed vocabulary learning practices we need to design adaptive narrative guidance, prompting learner action only when this is not forthcoming and fading prompts in response to learners adopting appropriate practices. We might prompt learners to add new vocabulary items if they do not do so for some time and not prompt them if they do, or prompt them to revisit and revise unchanging vocabulary records but not records that they do change, or similarly prompt (or not) sharing and collaboration around inquiries. However, it is not the prompts we design but how learners interpret them and react that is critical. This is one motivation for a participatory approach. Learner narratives inform our initial design and we are now moving towards involving learners in refining this design. We have described and demonstrated versions of our design to some interview participants and several were enthusiastic about participating in formative evaluations. Through these evaluations of functional prototypes we aim to acquire new stories. Analysis of these stories, employing the approach described here, will reveal new practices and challenges leading to revised designs.

In this paper, we hope to have demonstrated value in using learners' narratives to inform design. For reasons of space, we told only one story. We believe that even a single story has value but the value of Ines' story for any individual reader will depend on what that reader brings to the story and how they interpret it. Similarly, its plausibility will likely depend on whether it resonates with readers' own experiences more than any claims that some number of others have validated our interpretation. However, our intended contribution

here is not the story itself but rather our approach to analysis of learners' narratives. We have demonstrated a way of charting Chronologically Ordered Interactions with Resource Ecologies in Narratives (COIREN). This approach highlights the knowledge to be learnt, the tools and people that can assist and the influence of physical and temporal environment on a learner's interactions with these resources. Our analysis of these interactions adapting contingency graphs (Suthers, Dwyer, Medina, Vatrpu, 2010) helps us identify design challenges.

In summary, we have demonstrated an approach that takes learner stories seriously and provided an example of how this informs the design of mobile software for language learning. The methods we employ, particularly the COIREN chart, may be of use to researchers using other kinds of temporal data, e.g. log files, observation records, video recordings. In future uses we intend to combine narrative and log data. We also see a role in fleshing out imaginary narratives envisaging future systems; here charts could help focus attention on resources, filters, transitions and contingencies across settings and episodes. One flaw in our approach is that while following some guidelines from narrative inquiry, we have failed to position ourselves in the narrative surrounding the story told here. Also, the focus on a single learner in our COIREN chart is a limitation. Ideally, charts would incorporate perspectives from all parties involved. Such charts would promote more careful consideration of each collaborators' individual context and how this affects personal and collaborative learning.

Endnotes

- (1) See http://en.wikipedia.org/wiki/Common_European_Framework_of_Reference_for_Languages
- (2) Ines is a pseudonym for the participant who told this story.
- (3) For stories about the possible origin of at sixes and sevens see http://en.wikipedia.org/wiki/At_sixes_and_sevens

References

- Benford, S., Giannachi, G., Koleva, B., & Rodden, T. (2009). From interaction to trajectories: designing coherent journeys through user experiences, *Proceedings of CHI 2009, the 27th international conference on Human factors in computing systems* (pp.709-718). New York: ACM
- Brna, P. (2008). In search of narrative interactive learning environments. In M. Virvou & L. C. Jain (Eds.) *Intelligent Interactive Systems in Knowledge-Based Environments* (pp. 47-74). Berlin: Springer
- Clandinin, D. J., & Connelly, F. M. (2000). *Narrative inquiry: Experience and story in qualitative research*. San Francisco: Jossey-Bass.
- Clandinin, D.J., Pushor, D., & Murray Orr, A. (2007). Navigating Sites for Narrative Inquiry. *Journal of Teacher Education*, 58(1), 21-35
- Kukulska-Hulme, A. (2007). Like stars in the firmament: language learning on mobile devices. In S. Granger (Ed.), *Optimizing the role of language in Technology-Enhanced Learning*. Louvain-la-Neuve, 4-5 October 2007. Retrieved from <http://en.scientificcommons.org/24859358>
- Kupperman, J., & Weisserman, G. (2000). Narrative Analysis of Two On-line Political Simulations. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Fourth International Conference of the Learning Sciences* (pp. 320-321). Mahwah, NJ: Erlbaum.
- Luckin, R. (2010). *Re-designing Learning Contexts: Technology-rich, Learner-centred Ecologies*. London: Routledge
- Luckin, R. (2003). Between the lines: Documenting the multiple dimensions of computer supported collaborations. *Computers and Education*, 41(4), 379-396.
- Mor, Y., & Noss, R. (2008). Programming as mathematical narrative. *Int. J. Cont. Engineering Education and Life-Long Learning*, 18(2), 214-233.
- Suthers, D., Dwyer, N., Medina, R., & Vatrpu, R. (2010). A framework for conceptualizing, representing, and analyzing distributed interaction. *Int. J. Computer-Supported Collaborative Learning*, 5(1), 5-42.
- Underwood, J., Smith, H., Luckin, R., du Boulay B., Holmberg, J., Kerawalla, L., & Tunley, H. (2006). When the NINF came home: guiding parents and children in the co-construction of narratives linking home and school learning. In Paul Brna (Ed.), *Proceedings of NILE 2006*. Retrieved from <http://www.cogs.susx.ac.uk/users/bend/papers/nile06.pdf>
- Underwood, J., Luckin, R., & Winters, N. (2011). miLexicon: Harnessing Resources for Personal and Collaborative Language Inquiry. In S. De Wannemacker, G. Clarebout, & P. De Causmaecker (Eds.), *Proceedings of ITEC 2010* (pp. 87-98). CCIS 126. Berlin: Springer.
- van Lier, L. (2007). Action-based teaching, autonomy and identity. *Innovation in Language Learning and Teaching*, 1(1), 46-65.
- Yukawa, J. (2006). Co-reflection in online learning: Collaborative critical thinking as narrative. *Int. J. Computer-Supported Collaborative Learning*, 1(2), 203-228.

Acknowledgments

Many thanks to all participants. This work is supported by EPSRC grant EP/E051847/1 – SCARLET

Case-based Learning in a Virtual Professional Training – Collaborative Problem Solving Activities and Outcomes

Birgitta Kopp, Melanie Hasenbein, Heinz Mandl, Ludwig-Maximilians-Universität, Department of Psychology
Leopoldstr. 13, D-80802 Munich, Germany

Email: birgitta.kopp@psy.lmu.de, melaniehasenbein@knowledge-online.com, heinz.mandl@psy.lmu.de

Abstract: This article deals with the analysis of the collaborative problem solving activities and the learning outcomes of five groups that had to solve two different complex cases. To measure the effects of the problem solving activities the learners' contributions were analysed in respect to four different problem solving activities. Results show that the learning process is dominated by two central activities. Furthermore the results prove that the groups show more overall problem solving activities within the more complex case than within the less complex case. The learning outcomes of the more complex case differ more between the groups than with the less complex case. At last it could also be shown that the overall problem-solving activities in most of the successful groups are higher than in the less successful groups. Additionally the more successful groups show more coordination-specific activities in the problem solving process than content-specific activities.

Objectives

Several studies have analyzed the problem solving activities in face-to-face groups. But this is not sufficiently investigated in virtual groups, yet. Therefore this article focuses on the analysis of the collaborative problem solving activities and the learning outcomes of five groups who participated in a virtual professional training while working on two different complex case tasks.

Theoretical Framework

Case-based learning as a problem-oriented learning method is more and more realized in professional trainings, particularly within virtual learning environments (Reinmann & Mandl, 2006). Case-based learning offers the possibility to work on authentic and complex problems (Heimerl & Loisel, 2005) and it has the intention to support the application and transfer of knowledge into real professional situations (Badke-Schaub & Frankenberger, 1999) which is especially emphasized by moderate constructivist approaches (Reinmann & Mandl, 2006). In our study, the problem-oriented learning method is characterized by two central aspects. Firstly, solving complex problems is crucial for acquiring knowledge in the collaborative learning situation as they have a large number of different cross-linked variables, and include novel situations as well as incomplete information. When solving such problems, learners are confronted with their daily professional practices which is motivating for their learning effort and thus for knowledge acquisition. Secondly, problem scenarios are presented as authentically and realistically as possible in order to depict the complexity of reality, to stimulate learners' prior knowledge, to acquire new knowledge with help of additional information needed to solve the problem, and to transfer this knowledge to new situations. The problem-oriented learning method was used to stimulate problem solving activities in collaboration.

Collaborative learning is a situation in which two or more persons learn or attempt to learn together (Dillenbourg, 1999). A virtual learning group is characterized by a computer supported communication which can take place synchronously or asynchronously. As an asynchronous medium the discussion forum allows small groups to work together more intensively on a certain task than within a synchronous medium (Gräsel, Bruhn, Mandl & Fischer, 1997). Additionally the asynchronous communication allows a time- and location-independent learning which is especially important for professional trainings. The term collaborative learning describes a variety of interactions between learners with the intention to achieve a common goal (Johnson & Johnson, 1996) defined by a task or problem that has to be solved together (Cohen, 1994).

As solving complex problems and working together in teams are part of our daily and professional life the way how to solve a problem collaboratively is of great interest. Different authors have proposed models for individual problem solving (e.g., Hayes, 1989; Putz-Osterloh, 1983). All these models contain a sequence of problem solving steps which should lead to successful problem solving. But how does problem solving turn out to be under collaborative conditions? Referring to the models of individual problem solving Wetzel (1995) has developed a model for problem solving in groups which considers apart from the problem solving activities for individuals certain collaborative activities for problem-solving in groups. According to Wetzel (1995) the following activities are of relevance for the collaborative problem solving process: The *content-specific problem solving activities* are important as an indication for content-relevant aspects. These are "*gathering information*" which means the collection and preparation of all information needed to solve a problem solving task (Mabry & Attridge, 1990) and "*developing a solution*" which includes the development of a problem solution on the basis

of the collected and prepared information (Resnick, Salomon, Zeitz, Wathen & Holowchak, 1993). Secondly the *coordination-specific problem solving activities* which are particular for problem solving in groups are of great importance to avoid process loss in coordination. These are “*planning the common proceeding*” (contributions concerning the distribution of tasks and the time planning) and “*steering the interaction process*” (contributions relevant for the whole proceeding during the problem solving task) (Wetzel, 1995).

Different studies in face-to-face groups could prove core-activities in a problem solving process (Stempfle & Badke-Schaub, 2002). The results show that content-specific as well as coordination-specific activities appear as definable steps in the problem solving process of groups. Accordingly, this study wants to answer the question how problem solving in groups turns out to be in a virtual learning environment while the groups were working on different complex case tasks.

Regarding the didactical design of case tasks different types of cases and different levels of complexity should be taken into consideration. There are two types of cases that are relevant for this study. One is the case-problem-method and the other is the real- or live-case-method (Heimerl & Loisel, 2005). Within the case-problem-method the problem and all relevant information are given. The focus lies on finding a problem solution. Within the live-case-method the learners have to bring in the problem as well as all information needed to solve the case themselves, e.g. out of their professional background. Another didactical aspect for designing cases is the degree of complexity (Grohmann, 1997). On the one hand there are “closed cases” which are characterized by detailed task instructions and concrete questions to structure the case tasks. On the other hand there are “open cases” where the learners have more freedom of action in solving the cases and the learning instructions are characterized by more open questions and less structured task descriptions.

To measure the success of the problem solving process, the results of the learning outcomes are of interest. For this study the following two qualities of knowledge are of relevance (De Jong, & Ferguson-Hessler, 1996): At first there is the “conceptual knowledge” which includes the knowledge and concepts referring to a certain domain, e.g. knowledge management. Secondly the “situative knowledge” refers to a specific problem situation. This kind of knowledge shows that the learner is able to identify the aspects which are necessary to solve a problem and which should finally help to apply the acquired knowledge in a similar problem situation.

The Virtual Professional Training

Object of the investigation was a virtual professional training on the topic of knowledge management for professionals in an automotive company. The intention of the virtual training was to impart theoretical concepts and models on the topic of knowledge management as well as practice-oriented knowledge by working on practical cases. The training was divided in four parts: two theoretical parts each composed of certain learning modules regarding the subject knowledge management and two collaborative parts in which the learners worked on their cases in their predefined virtual groups. The virtual training on the topic of knowledge management was didactically designed according to the principles of problem-oriented learning with the focus on the collaborative case tasks, namely authenticity and learning in a social context, multiple contexts and multiple perspectives, as well as instructional support.

The Cases in the Virtual Training

The first case “Metallina” was compiled with the case-problem-method. This was a predetermined case taking place in the maintenance planning of a metal working company. Problem and information were given as well as detailed instructions for handling this case. The groups had the task to develop a solution to improve the knowledge management problem in the maintenance department of that company.

The second case was a real- or live-case-method. Real implies that the groups chose a case which presented a real knowledge management problem in their department or company, e.g. a knowledge sharing problem in a certain project. Information and problem of the cases were proposed by the group members themselves. Here the groups didn’t get such a detailed instruction as for the first case. In comparison with the first case the task was less pre-structured and the learners got more open questions.

Technical Realization of the Virtual Training

The virtual training was realized on a web-based learning environment. On the learning platform the learners had access to the tutorials of the different learning modules and to protected working sections which were only accessible for the participants of a defined group. In this working section the groups got their case instructions and could work on their cases in their own discussion forums.

Research Questions

1. To what extent do problem solving activities exist in the two cases?
2. How do the problem solving activities differ in the two cases?
3. How successful were the two cases solved?
4. How do the groups’ learning outcomes differ regarding the problem solving activities?

Method

Sample and Design

The investigation of this study refers to the 18 professionals of the virtual training on the topic of knowledge management. 14 participants were male and four were female. The average age was 38 years. The subjects formed three groups with three members, one with four and one with five members. One group dropped out after the first case "Metallina". So the data of that group couldn't be included for the analysis of the Real-Case.

Data Collection

For analysing the learning process the problem solving activities were divided in two categories "content-specific" and "coordination-specific" activities. The categories were analysed with a special coding scheme which included the two content-specific activities "gathering information" (e.g. „What do you exactly mean by that?“) and "developing a solution" (e.g. "I agree with your suggestion to focus on the groups which are involved") as well as the two coordination-specific activities "planning the common proceeding" (e.g. „Who works on which part?“) and "steering the interaction process" (e.g. „Please, look in the concept of our documentation“). The unit of analysis was one statement. The coding scheme was validated by a second evaluator who double-rated 20 per cent of all contributions. The interrater correlation was .84.

The learning outcomes were analysed according to the *conceptual* and *situative* knowledge with a specific analysis scheme and rating instrument. For the *conceptual knowledge* the experts evaluated the theoretical contributions in the case solutions. For every correct theoretical aspect the groups got one point. At the end all correct aspects were added. For the evaluation of the *situative knowledge* the degree of problem solving was rated by means of a six-scale between "not solved" and "exactly solved". Here the evaluator rated to what extent the offered solution was adequate to really solve the present case problem or not. The interrater correlations were .96 for measuring the conceptual knowledge and .98 for rating the situative knowledge.

Results

Research Question 1: Extent of Problem Solving Activities in the Two Cases

Regarding the problem solving activities during both cases, "developing a solution" and "steering the interaction process" were most important while "gathering information" and "planning the common proceeding" played a minor role in most of the groups.

Table 1. Problem solving activities of the case "Metallina" and the Real-Case in per cent.

Cases	Gathering information		Developing a solution		Planning the common proceeding		Steering the interaction process	
	Metallina	Real	Metallina	Real	Metallina	Real	Metallina	Real
Group 1	8.33	15.39	25.00	28.85	33.33	17.31	33.33	38.46
Group 2	23.53	28.85	29.41	40.00	23.53	20.00	23.53	25.00
Group 3	5.00	17.31	35.00	38.10	20.00	14.29	40.00	33.33
Group 4	11.77	38.46	47.06	36.36	11.77	18.18	29.41	40.91
Group 5	6.25		31.25	--	12.50	--	50.00	--

Research Question 2: Differences of Problem Solving Activities in the Two Cases

Looking at the absolute numbers of the problem solving activities the results in all groups apart from group 1 are almost similar in both cases (see table 2). Comparing the results of the two cases groups show more overall problem solving activities within the real-case than within the first case. This result confirms the assumption that a greater amount of problem solving activities is found within the second and more complex real-case due to the fact that a real problem situation has different and a larger amount of dependent variables.

Table 2. Content- and coordination-specific problem solving activities of the two cases in absolute numbers.

	Case "Metallina"		Real-Case	
	Content-specific	Coordination-specific	Content-specific	Coordination-specific
Group 1	12	24	23	29
Group 2	9	8	11	9
Group 3	8	12	11	10
Group 4	10	7	9	13
Group 5	6	10	--	--

Research Question 3: Outcomes of the Cases

Looking at the learning outcomes of the case “Metallina” (see table 3) all groups show similar results in respect to the conceptual and situative knowledge. Regarding the learning outcomes of the real-case the groups show a more heterogeneous picture concerning the conceptual and situative knowledge, which was assumed, because of e.g., a higher degree of complexity, and a less detailed instruction.

Table 3. Learning outcomes of the two cases in per cent.

	Case “Metallina”		Real-Case	
	Conceptual	Situative knowledge	Conceptual	Situative knowledge
Group 1	62.50	80.00	76.00	80.00
Group 2	52.50	60.00	24.00	40.00
Group 3	57.50	80.00	20.00	40.00
Group 4	47.50	60.00	52.00	60.00
Group 5	60.00	80.00	--	--

Research Question 4: Differences in Success and Problem Solving Activities

“Successful groups” are those groups which learning outcomes were over the groups’ average in respect of the conceptual and the situative learning outcomes. For the first case these are groups 1, 3 and 5, for the Real-Cases these are the groups 1 and 4 (see table 4 and 5). The groups whose learning outcomes were below the groups’ average are described as “less successful groups” (groups 2 and 4 for case “Metallina”, groups 2 and 3 for Real-Cases). The successful groups show more problem-solving activities than the less successful groups in spite of group 5 for the case “Metallina”. Furthermore, all successful groups in both cases show more coordination-specific activities than content-specific activities in comparison with the less successful groups.

Table 4. Problem solving activities for successful and less successful groups in absolute numbers (“Metallina”).

	Successful groups			Less successful groups	
	Group 1	Group 3	Group 5	Group 2	Group 4
Content-specific	12	8	10	9	10
Coordination-specific	24	12	6	8	7

Table 5. Problem solving activities for successful and less successful groups in absolute numbers (Real-Case).

	Successful groups		Less successful groups	
	Group 1	Group 4	Group 2	Group 3
Content-specific	23	9	11	11
Coordination-specific	29	13	9	10

Summary of Results and Discussion

Overall this descriptive study could give an insight into the collaborative problem solving activities and learning outcomes of two different complex case tasks in a virtual learning environment. The main activities in both cases were “*developing a solution*” and “*steering the interaction process*”. The results show that also in virtual groups the core of certain problem solving activities can be found as it is already shown in face-to-face groups (Stempfle & Badke-Schaub, 2002). The importance of the activity “*developing a solution*” proves the relevance of the development of a common solution space within a collaborative task (Gruenfeld & Hollingshead, 1993). The importance of “*steering the interaction process*” could be due to the fact that the professional training took part in a virtual room that requires more coordination than face-to-face situations (Fischer & Waibel, 2002). This could be explained with the missing non-verbal and paraverbal signals in virtual learning environments (Kiesler, Siegel & McGuire, 1984). Furthermore according to the expectations the groups show a greater amount of problem solving activities within the real-case than within the first case which supports the thesis that a more complex real-case with many interdependent variables requires more activities to solve the problem.

Regarding the learning outcomes, the results were more heterogeneous within the real-case than within the case “Metallina” as assumed. That shows that a more complex case from the professional context of the participants is related with higher requirements for the learners (Gruenfeld & Hollingshead, 1993). Furthermore it has to be taken into consideration that the self-chosen real-cases differed in their level of complexity. This could be a reason why the learners within a less complex case did not refer to as much theoretical concepts.

The assumption that the successful groups show more problem solving activities than the less successful groups could be proven for most of the groups in both cases. Additionally a pattern was found that

the successful groups show more coordination-specific activities than content-specific activities. This result shows the relevance of coordination-specific activities for successful problem solving in virtual groups.

In terms of limitations of this investigation further studies with bigger samples could show if there can be found certain similarities regarding the problem solving activities in virtual groups as well as in other virtual settings. Additionally bigger samples would allow finding correlations between single problem solving activities and the learning outcomes. Limitations of this study can also be seen in the comparability of the real-cases the groups had to choose by themselves. Therefore in further studies there should be more focus on the level of complexity of the different real-cases giving more instructions regarding content, structure or size.

Furthermore on a didactical level the learners could be supported with scripts that could help them with strategies to solve the cases. Additionally with social scripts the coordination activities which were very high in both cases could be reduced in support of more content-related activities. Finally it could be recommended for virtual trainings of this kind to integrate classroom courses in terms of a blended learning concept. This would on the one hand allow the group members to get to know each other as well as to clarify certain questions, e.g. regarding content and responsibilities of the case tasks face-to-face. On the other hand the learners could get more instructional support during the classroom courses to help them solving the cases.

Importance of Study and Outlook

Case-based learning in virtual learning environments especially within professional trainings allows working on authentic and complex problems in a social context. Regarding the collaborative learning in virtual environments there is further research needed. This study is a contribution to the analysis of certain problem solving activities in virtual groups while they were working on different complex cases as well as to their learning outcomes. Furthermore the study could make a methodical contribution to the analysis of problem solving activities in virtual groups as it is already investigated in face-to-face groups. Additional studies should show if the results of this study can be transferred to other virtual settings and into other domains.

References

- Badke-Schaub, P. & Frankenberger, E. (1999) Analysis of design projects, *Design Studies*, 20, 481-494.
- Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64, 1-35.
- Dillenbourg, P. (1999). Introduction: What do you mean by 'collaborative learning'? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1-15). Oxford: Elsevier.
- De Jong, T. & Ferguson-Hessler, M. G. M. (1996). Types and qualities of knowledge. *Educational Psychologist*, 31 (2), 105-113.
- Gräsel, C., Bruhn, J., Mandl, H. & Fischer, F. (1997). Lernen mit Computernetzen aus konstruktivistischer Perspektive. *Unterrichtswissenschaft*, 25 (1), 4-18.
- Grohmann, S. (1997). Die Fallmethode. Theoretische Grundlagen. In J. Aff & M. Wagner (Hrsg.), *Methodische Bausteine der Wirtschaftsdidaktik*. Wien: Manz.
- Gruenfeld, D. H. & Hollingshead, A. B. (1993). Sociocognition in work groups: The evolution of group integrative complexity and its relation to task performance. *Small Group Research*, 24, 383-405.
- Hayes, J. R. (1989). *The complete problem solver*. Hillsdale: Erlbaum.
- Heimerl, P. & Loisel, O. (2005). *Lernen mit Fallstudien in der Organisations- und Personalentwicklung: Anwendungen, Fälle und Lösungshinweise*. Wien: Linde.
- Johnson, R. T. & Johnson, D. W. (1996). Cooperation and the use of technology. In D.H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 1017-1044). New York: Macmillan.
- Kiesler, S., Siegel, J. & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist*, 39 (10), 1123-1134.
- Mabry, E. A. & Attridge, M. D. (1990). Small group interaction and outcome correlates for structured and unstructured tasks. *Small Group Research*, 21, 315-332.
- Putz-Osterloh, W. (1983). Über Determinanten komplexer Problemlöseleistungen und Möglichkeiten zu ihrer Erfassung. *Sprache und Kognition*, 2, 100-116.
- Reinmann, G. & Mandl, H. (2006). Unterrichten und Lernumgebungen gestalten. In A. Krapp & B. Weidenmann (Hrsg.), *Pädagogische Psychologie* (S. 613-658). Weinheim: Beltz PVU.
- Resnick, L. B., Salmon, M., Zeitz, C. M., Wathen, S. H. & Holowchak, M. (1993). Reasoning in conversation. *Cognition and Instruction*, 11, 347-364.
- Stempfle, J. & Badke-Schaub, P. (2002). Kommunikation und Problemlösen in Gruppen: eine Prozessanalyse. *Gruppendynamik und Organisationsberatung*, 33 (1), 57-81.
- Wetzel, J. (1995). *Problemlösen in Gruppen: Auswirkungen von psychologischen Trainingsmaßnahmen und Expertenbeteiligung unter kooperativen und kompetitiven Arbeitsbedingungen*. Dissertation. Technische Universität Carolo-Wilhelmina, Braunschweig.

Online Smart “Discussion Forum” – An Environment for an Effective Task-based Collaborative Discussion among the Adult Learners

Nantha Kumar Subramaniam, Open University Malaysia (OUM), Jalan Tun Ismail 50480 Kuala Lumpur, Malaysia, nanthakumar@oum.edu.my

Abdullah Mohd Zin, Sufian Idris, University Kebangsaan Malaysia (UKM), 43600 UKM Bangi, Selangor, Malaysia

Email: amz@ftsm.ukm.my, si@ftsm.ukm.my

Abstract: Asynchronous online discussion forums play an important role in adult online courses, and have many possible functions. Our experience in using the discussion forums in online courses for task-based collaborative discussion has led us to many questions about the optimal ways of using online discussion to support collaborative learning, such as how should instructors structure online discussions in a way that it promotes collaborative learning? What should instructors do to enhance learners’ reflective thinking, critical thinking, or problem solving in online collaborative discussions? The challenges of using forum in learning also have been highlighted by many researchers. In this paper we present “smart” discussion forum to support, monitor and facilitate task-based collaboration for the learning process of the adult learners to advance their development of critical thinking.

Introduction

Online learning in open and distance learning which caters adult learners is different from traditional face-to-face learning in many ways. One obvious difference is that there are lack of direct face-to-face interactions among students or between students and instructor (Gao, 2009) The quality and quantity of student-student interaction and student-instructor interaction influence the quality for any course, online or face-to-face. In this regard, one of the challenges to teach online is to cultivate meaningful online interactions among the adult students who have diversified background (Gao, 2009). To achieve this goal, the asynchronous online discussion forum is one of the most effective tools, as it promotes reflection, frees learners from time and space constraints (Anderson, 1996) and provides abundant possibilities for communication. In online courses for adult learners, discussion forums have been used for a variety of purposes such as to discuss general issues of the subject matter; share and obtain resources and information from each other and more importantly act as centers for groups of students who work collaboratively on task assigned to them (Gao, 2009).

Problem Statement

Asynchronous online discussion forums play an important role in adult online courses, and have many possible functions (Dennen, 2008). At the same time, our experience in using discussion forums in online courses for task-based collaborative learning has led us to many questions about the best possible ways of using online discussion to support collaborative learning, such as how should instructors structure online discussions in a way to promote collaborative learning? What should instructors do to enhance reflective thinking, critical thinking, or problem solving in online collaborative discussions? The reality in online discussion forums, however, does not always live up to these expectations (Gao, 2009). This is more so for online task-based collaborative learning implemented through discussion forum. When asynchronous discussion forum is used to support the understanding of the subject matter among the learners, there have seen both successful and unsuccessful situations (Gao, 2009). There are times when passionate discussions started with one student sharing a piece of reminiscent experience, when discussions came alive with a thought-provoking question, and when a group of students argued keenly about their ideas. There are also times, however, when discussions failed to achieve the preferred goal (Gao, 2009). In this paper we discuss how we have designed and developed a “smart” discussion forum to support, monitor and facilitate task-based collaboration for the learning process of the adult learners to advance their development of critical thinking.

Literature Review

Various collaborative tools have been developed to support learning and discussion among the learners. The comparison of some of the tools commonly cited in the literatures and tool that we have developed is given in Table 1.

Table 1: Comparison of various CSCL tools widely cited in the literature.
(Adapted from Soller et al., 2005).

Tool	Platform	Task	Performance Indicator	Roles	Pedagogical Constructs applied in the Tool
COLER (Constantino-Gonzales & Suthers, 2000)	Real Time non-Forum	Concept Learning	Participation, Agreement with group procedure	Coach	Collaborative Learning
iDCLE (Inaba & Okamoto, 1996)	Real Time non-Forum	Concept Learning	Advice	Coach	Collaborative Learning
Gracile (Ayala & Yano, 1998)	Real Time non-Forum	Concept Learning	Appropriate student helpers , Learning tasks	Coach	Collaborative Learning, Zone of Proximal Development (ZPD)
HabiPro (Vizcaino et al., 2000)	Real Time non-Forum	Concept Learning	Ideal participation, Motivation	Coach	Collaborative Learning
LeCS (Rosatelli et al., 2000)	Real Time non-Forum	Concept learning	Participation, Group Coordination	Coach	Collaborative Learning
Group Leader (McManus & Aiken, 1995)	Real Time non-Forum	Concept Learning	Trust, Leadership, Communication	Coach	Collaborative Learning, Sentence Opener
Epsilon (Soller & Lesgold, 2000)	Real Time non-Forum	Concept Learning and Problem Solving	Knowledge Construction	Coach	Collaborative Learning, Knowledge Construction, Problem Solving Actions, Sentence Openers
<i>Our proposed "smart forum"</i>	Asynchronous - Forum	Problem solving	Critical Thinking	Coach	Scaffolding using sentence opener, Community of Inquiry, Problem-based Learning, Critical Thinking Model, Collaborative Learning

Design & Implementation

In this section, the design framework and implementation of the proposed smart forum environment are discussed. The proposed architecture of the system will use agent approach which is based on the rule-based expert system framework. Agent approach is adopted as it is goal oriented, take action when necessary to fulfill the goal, capable to perform tasks given by the user autonomously, monitor the environment and adjust an event without direct intervention from the user. Figure 1 shows the components that make up the proposed system. It has seven agents performing different tasks. The facts and rules for the agents will be stored in the knowledge base and Java class programs respectively. In smart forum, the students are given a task or problem to be solved through collaborative discussion in a small group. In order to engage in the discussion, the students will post their messages in the asynchronous forum using sentence openers provided in the forum. Only one sentence opener can be used per posting to start the discourse. Subsequent sentence(s) in the same posting should not use any sentence opener. There is no restriction on the number of words per posting but each posting (which may consists of more than one sentence) must highlight a *single issue*. This will enable the agents to do their tasks efficiently. Sentence openers are pre-defined approach to start a conversation using menu or buttons.

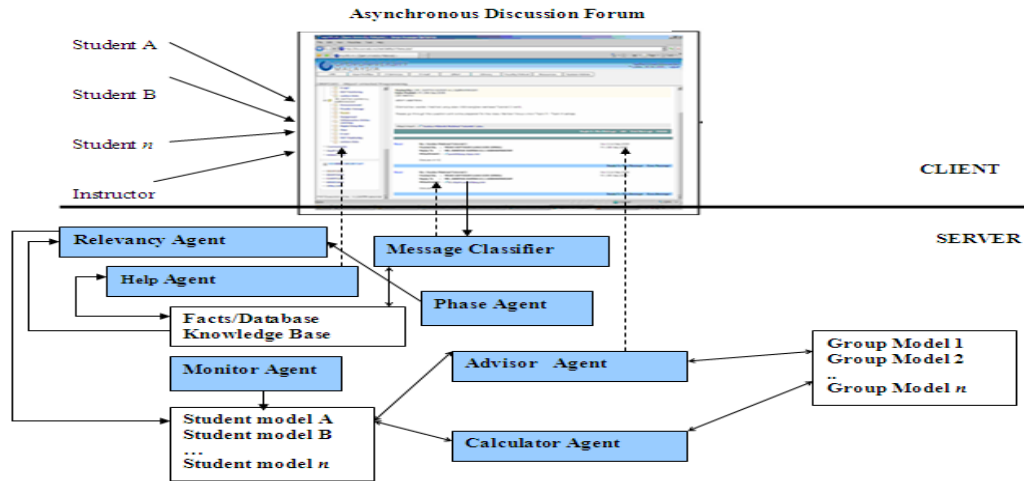


Figure 1. Architecture of the Smart Forum.

We are motivated to use sentence openers based on the result obtained by Baker & Lund (1996). In this study, the sentence opener that have been adopted is based on the Collaborative Skills Network (CSN) proposed by Israel (2003). Israel (2003) model is adopted as it has included more “working on task” sentence opener which are appropriate for task-based discussions. In our proposed expert system, each message typed by the students using the sentence openers will first be parsed by the *Message Classifier* agent that will do the following tasks:

- i. Identify which sentence opener that has been used by the students and the tutors. Tutors and students are given separate set of sentence openers (Figure 2).
- ii. Identify the main keywords used by the students in completing the sentence (sentence closer) using the sentence opener. The analysis is done using Knuth-Morris-Pratt string matching algorithm.
- iii. Based on the sentence opener and sentence closer used by the students, the agent will classify the message as either *discussion messages*, *not relevant message* (such as “how are you?”) or *specific question* from the students on the domain or problem that need to be solved. The agent will ignore any other message that could not be classified.
- iv. If the message is classified as discussion message, the agent will assign appropriate tag(s) available in Newman’s content analysis model (Newman et al., 1995). Here a message can have more than one indicator depending on the keyword used in the sentence closer.

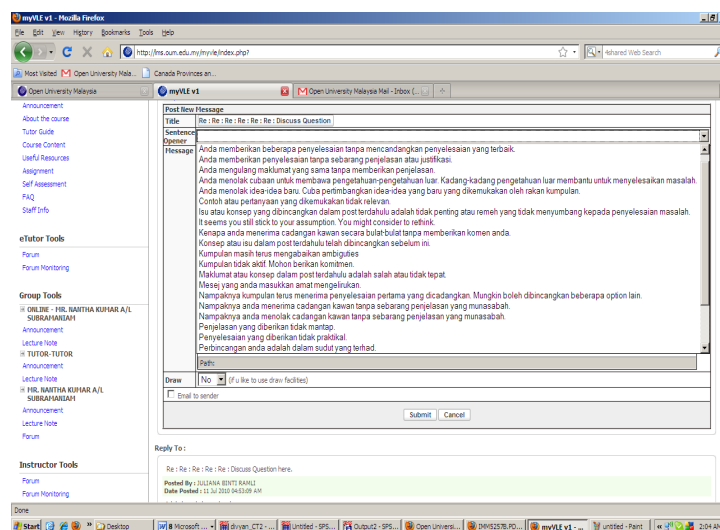


Figure 2. Sentence Openers are Provided as Pull-down Menu (Student View).

Calculator Agent will Calculate the critical thinking (CT) ratio of the individual learner and the groups for each of the category in the Newman’s content analysis model. (Newman et al., 1995). In calculating the CT ratio, messages that relevant to the groups’ current phase in the Garrison’s “practical inquiry model” (Garrison

et al., 2001a; Garrison et al., 2001b) will be taken into consideration. Other messages which are considered to be not relevant for the current phases will be ignored. Calculator agent will also calculate the cumulative CT ratio of the learners and groups independent of the phases. The *Monitor Agent* will monitor students' participation level in the discussion forum. This agent will send postings/message or reminders in the forum to the students who are not active by asking them to participate actively in the discussions in a week. This is to ensure that there are plenty of postings so that other agents can perform their tasks. The formula used to determine student activeness is based on the learners' out-degree centrality of their discussion (Suh & Lee, 2006). Learners with high out-degree centrality are more active in providing information to others in discussion or providing comments on the opinions of others. Newman et al. (1995) also have mapped the relevant indicators of content analysis to each of the phase in the Garrison's "practical inquiry" model. If a message is tagged by the Classifier agent, the *Relevancy Agent* will use this mapping information to update the relevant parameters in the student model regarding the status of the current message posted by the learners (i.e. whether the message is appropriate for the current phase or not). This is to ensure that the students are in the same level of discussion and there are no students ahead or left out in the discussion. The *Phase Agent* will keep track in the transition of the phases in the Garrison's "practical inquiry" model. Only the tutor is allowed to change the phase of the group and the Phase agent will notify the relevant agents if there is any change of phase for the groups. The Phase agent will also identify in which phase a message has been posted by the student. This information is vital for the Relevancy agent. Phase agent has influence on the Calculator and Relevancy agents as information from Phase agent is used by these two agents in executing their tasks. The *Help Agent* will provide possible answers for the students queries on the subject matter in the form of FAQs in a new pop-up window. If the agent could not give the possible answers or if the student is not happy with the answers given by the agent, the student has the option to alert the tutor by just clicking an alert button provided by the agent on the same screen. When this is done, the agent will send the user's searched keyword together with their email to the tutor. The tutor can then reply to the student with the appropriate answer.

Information in students' and groups' model will be updated accordingly by the relevant agents as they perform their tasks. The student model for each of the student stored in the database table consists of the following information: CT ratio of the phase, overall CT ratio, magnitude of the learners activeness (out-degree centrality ratio), indicator of relevant message tags posted in a message for a phase, the learners CT ratio of the prior phase and information on the relevant tags for the latest posting. The group model will consist of the following information: overall CT ratio of the groups, CT ratio for the each phase, CT ratio of the group's prior phase. Finally, the *Advisor Agent* will swing into action to do the following tasks using all the messages classified as *discussion messages* and has been tagged by the Message Classifier agent earlier:

- i. Monitor learners' and groups' CT ratio in moving from one phase to the another
- ii. Based on (i) above and the status of the students and groups model, the Advisor agent will give its feedback, advice or consultation to the students or/and their group (Figure 3).
The message or feedback from this agent to the student or the group will consist of three sections in a single message:
 - The current status of the learners or the group
 - How they can overcome their problem if there is a deadlock in the group or the individual student
 - The current rank of their performance and their past performance (in the form of percentage from 0 to 100)

In addition, the Advisor agent will alert the groups if they are spending too much time in a particular phase

Conclusions and Future Work

This paper has present an architecture for smart forum prototype which support, monitor and facilitate adult learners task-based collaborative discussion. The system was built using agent approach utilizing the very natural set-up of forums to enhance adult learners critical thinking in solving a task/problem online collaboratively. The initial feedback from the students show that the system has contributed to the enhancement of their capability and critical thinking on the subject matter. We are currently investigating the ways to incorporate fuzzy logic and neural network in the system in order to increase the processing power of the agents.

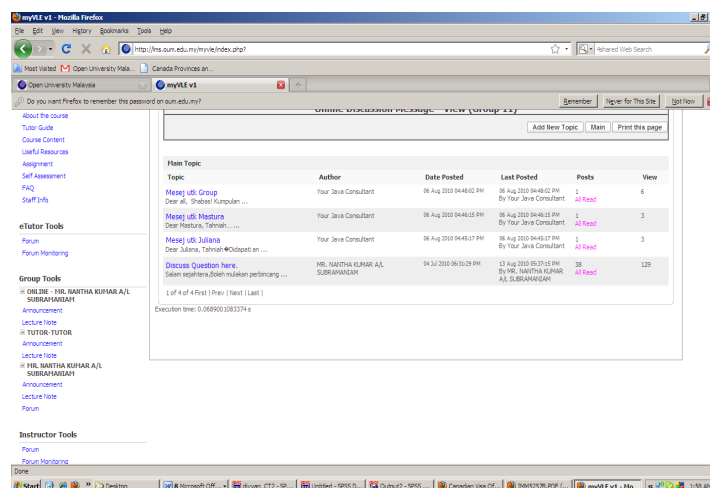


Figure 3. Agent Drafted Responses Sent to the Individual Student and Group.

References

- Anderson, T. (1996). The virtual conference: Extending professional education in cyberspace. *International Journal of Educational Telecommunications*, 2(2/3), 121-135.
- Ayala, G., & Yano, Y. (1998). A collaborative learning environment based on intelligent agents. *Expert Systems with Applications*, 14, 129-137.
- Baker, M., & Lund, K. (1996). Flexibly structuring the interaction in a CSCL environment. *Proceedings of the European Conference on Artificial Intelligence in Education (EuroAIED '96)*, 401-407.
- Constantino-Gonzalez, M., & Suthers, D. (2000). A coached collaborative learning environment for Entity-Relationship modeling. *Proceedings of the 5th International Conference on Intelligent Tutoring Systems*, Montreal, Canada, 324-333.
- Dennen, V. P. (2008). Looking for evidence of learning: Assessment and analysis methods for online discourse. *Computers in Human Behavior*, 24(2), 205-219.
- Gao, F. (2009). *Fostering focused online discussions*. ProQuest Dissertations and Theses, <http://search.proquest.com/docview/304952625?accountid=48462>. Accessed 8 Sept 2010.
- Garrison, D. R., Anderson, T., & Archer, W. (2001a). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, 2(2-3), 87-105.
- Garrison, D. R., Anderson, T., & Archer, W. (2001b). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education*, 15 (1) 7-23.
- Inaba, A., & Okamoto, T. (1996). Development of the intelligent discussion support system for collaborative learning. *Proceedings of ED-TELECOM '96*, Boston, MA, 137-142.
- Israel, Judith Lynne. (2003). *Collaborative learning enhanced by an intelligent support system*. Doctoral Dissertation. Temple University,
- McManus, M. & Aiken, R. (1995). Monitoring computer-based problem solving. *Journal of Artificial Intelligence in Education* 6(4), 307-336.
- Newman, D. R., Webb, B., & Cochrane, C. (1995). A content analysis method to measure critical thinking in face-to-face and computer supported group learning. *Interpersonal Computing and Technology*, 3 (2), 56-77.
- Rosatelli, M., Self, J., & Thirty, M. (2000). LeCs: A collaborative case study system. *Proceedings of the 5th International Conference on Intelligent Tutoring Systems*, Montreal, Canada, 242-251.
- Soller, A., Alejandra Martinez, Patrick Jermann, and Martin Muehlenbrock. (2005). From Mirroring to Guiding: A Review of State of the Art Technology for Supporting Collaborative Learning. *Int. J. Artif. Intell. Ed.* 15, 4 261-290.
- Soller, A., Jermann, P., Muehlenbrock, M., & Martinez, A. (2004). Designing Computational Models of Collaborative Learning Interaction. *Proc. ITS 2004 Workshop*, 5-12.
- Soller, A., & Lesgold, A. (2000). Knowledge acquisition for adaptive collaborative learning environments. *Proceedings of the AAAI Fall Symposium: Learning How to Do Things*, Cape Cod, MA.
- Suh, H.J., & Lee, S.W. (2006). Collaborative learning agent for promoting group interaction. *Electronics Telecommunications Research Institute (ETRI) Journal*, 28(4), 461-474.
- Vizcaino, A., Contreras, J., Favela, J., & Prieto, M. (2000). An adaptive, collaborative environment to develop good habits in programming. *Proceedings of the 5th International Conference on Intelligent Tutoring Systems*, Montreal, Canada, 262-271.

Collaborating in a Virtual Engineering Internship

Cynthia D'Angelo, Golnaz Arastoopour, Naomi Chesler, and David Williamson Shaffer, University of Wisconsin - Madison, 1025 West Johnson Street, Suite 499, Madison, WI 53706
Email: cmdangelo@wisc.edu, arastoopour@wisc.edu, chesler@engr.wisc.edu, dws@education.wisc.edu

Abstract: Teamwork and collaboration are vital 21st century skills that students need to master. Specially designed epistemic games modeled after professional practica can help students build and practice these skills. This paper presents preliminary results from a virtual engineering internship, an epistemic game for introductory engineering undergraduates. The game was designed to help build students' skills in teamwork and collaboration while providing experiences relevant to engineering and design. After the internship students reported a better understanding of what engineers do and about the practice of engineering. Students also made content learning gains. Students overwhelmingly enjoyed the experience and felt encouraged to stay on an engineering career path.

Introduction

STEM expertise in the 21st century requires complex problem solving that goes well beyond the basic facts and skills that traditional tests were designed to assess (National Academy of Sciences, 2005; Shaffer, 2004b). These 21st century skills include collaboration, innovation, and creativity. Real-world STEM problem solving involves generating links between STEM skills and knowledge on the one hand, and the values and ways of making decisions that characterize STEM professions on the other.

Epistemic games are computer simulations of STEM practices that develop the epistemic frames of STEM professionals (Beckett & Shaffer, 2005; Hatfield & Shaffer, 2006; Svarovsky & Shaffer, 2007). These games thus represent a promising approach to STEM learning because: (1) epistemic games are based explicitly on authentic STEM practices, and thus provide information about STEM problem solving, (2) epistemic games are computer simulations, and they record rich data about STEM problem-solving processes that take place during game play, and (3) epistemic games are designed based on the *epistemic frame hypothesis*, a theory of learning that analyzes thinking in terms of connections among *frame elements*: skills, knowledge, values, and justification or decision-making (otherwise known as *epistemology*) of a STEM profession.

We have developed *Nephrotex* as a virtual simulation of authentic engineering practice to give undergraduates an opportunity to work as engineers and see the relationship between basic engineering skills and knowledge and the values that underlie the profession. A key part of this professional experience is collaborating and working on teams to design a product. The biomedical engineering aspect of *Nephrotex*, in which the task is to design a next-generation hemodialysis ultrafiltration membrane, was selected to make real the ability of engineers to improve health care.

The research question explored by these preliminary analyses looks at whether or not the game is successful in fostering teamwork and collaboration in engineering students. This paper describes current progress on implementing *Nephrotex*, analysis of preliminary results from the first implementation, and discussion of future analyses that will be performed to better understand how the game builds the skills of teamwork and collaboration.

Nephrotex: A Virtual Internship

Nephrotex was created to increase the persistence of engineering undergraduates in pursuit of degree attainment. It is modeled on authentic engineering practices, has been pilot-tested, and has now been incorporated into a first-year engineering undergraduate course at the University of Wisconsin–Madison.

Nephrotex is not designed specifically for biomedical engineers but instead for any student who might someday work in a team, design a product, answer to multiple clients, and be forced to find the solution that “satisfices.” This game is potentially transformative because it addresses a key aspect of engineering education (professional practice), as well as critical limiting factors in providing students with opportunities for experiencing professional practice (faculty time and institutional resources).

Learning Theory

Nephrotex is grounded in the epistemic frame hypothesis, which suggests that any professional community has a culture (Rohde & Shaffer, 2004; Shaffer, 2004a, 2005, 2006) and that culture has a grammar: a structure composed of *skills* (the things that members of the community do), *knowledge* (the understandings that members of the community share), *values* (the beliefs that members of the community hold), *identity* (the way that members of the community see themselves), and *epistemology* (the warrants that justify actions or claims as legitimate within the community). This collection of skills, knowledge, values, identity, and epistemology forms

the epistemic frame of the community. The epistemic frame hypothesis suggests that (a) an epistemic frame binds together the skills, knowledge, values, identity, and epistemology that an individual takes on as a member of a community of practice; (b) such a frame is internalized through the training and induction processes by which an individual becomes a member of the community; and (c) once internalized, the epistemic frame of a community is used when an individual approaches a situation from the point of view (or in the role) of a member of the community (Shaffer, 2004a, 2005).

Put in more concrete terms, engineers act like engineers, identify themselves as engineers, are interested in engineering, and know about physics, electricity, mechanics, chemistry, and other technical fields. These skills, affiliations, habits, and understandings are made possible by looking at the world in a particular way: by thinking like an engineer. The same is true for biologists but for different ways of thinking—and for mathematicians, computer scientists, science journalists, and so on, each with a different epistemic frame.

The key step in developing the epistemic frame of most professional communities is some form of professional practicum (Schon, 1983, 1987). Professional practica are environments in which a learner takes professional action in a supervised setting and then reflects on the results with peers and mentors. Skills and knowledge become more and more closely tied as the student learns to see the world using the epistemic frame of the community. Examples include capstone design courses in undergraduate engineering programs, medical internships and residencies, and almost any STEM graduate program.

Thus, one way to give students a realistic understanding of a profession early in their undergraduate careers is to create a virtual simulation of a professional practicum, which is what *Nephrotex* is designed to do.

Internship Activities

In *Nephrotex*, students become interns in the fictitious company Nephrotex, whose core technology is the ultrafiltration unit, or dialyzer, of a hemodialysis machine. The students' assigned task is to design a next-generation dialyzer membrane. This task is assigned to them by the head of research and development, a virtual nonplayer character, and explained to them in depth by their engineering manager, a nonvirtual nonplayer character (i.e., a real person playing a role in the game). To redesign the dialyzer unit, four aspects of the hollow fiber material can be altered: the base polymer, percent carbon nanotubes, material processing method, and surfactant. If students choose to test a combination of these parameters, their choices serve as the input to a "black box" that yields the following outputs or performance characteristics: biocompatibility, marketability, reliability, ultrafiltration rate, and cost (Figure 1).

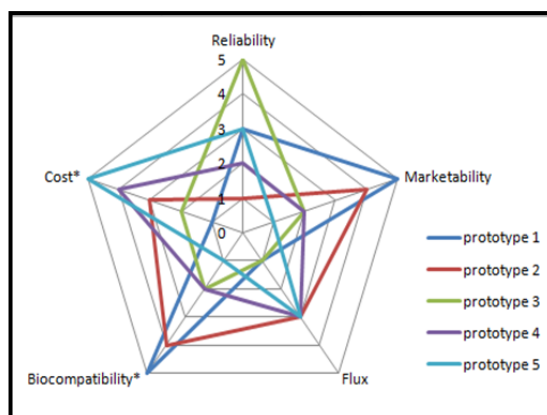


Figure 1. A Graph Based on the Outputs the Students Have to Consider When Designing Their Prototype.

Students first familiarize themselves with the virtual environment by completing an intake interview, writing a staff page biography, and reading others' staff pages. They then explore a portion of the design space by performing a preliminary data analysis of variations in output parameters for one material based on changes in percent carbon nanotubes, processing method and surfactant, i.e., the other input parameters. Students work in small groups and are guided by a design advisor, a nonvirtual nonplayer character with whom they interact through an email and Internet chat system built into the simulation. Teams proceed through design-build-test cycles, first with just one material and subsequently with all materials, including all possible values of all input parameters (see Figure 2). They receive feedback on designs from virtual nonplayer characters with an interest in the project—a clinical engineer, a manufacturing engineer, a focus group liaison, and representatives from marketing and product support—all of whom are programmed to evaluate students' design choices. At the end of each design phase, students make a recommendation and justify their choice based on how it satisfies the competing demands of these stakeholders. One key element of the game is that there is no optimal solution—that is, no solution that both minimizes cost and maximizes the other performance criteria. The students must find and justify the solution that "satisfices."

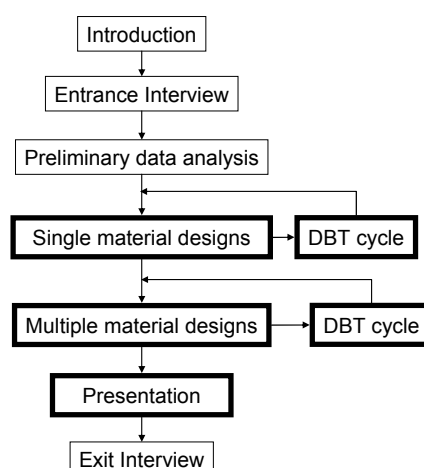


Figure 2. Nephrotex work flow diagram. Light borders around boxes indicate individual work; heavy borders indicate teamwork. DBT = design-build-test cycle.

Furthermore, to make it simple to implement in a first-year introduction to engineering course, the game includes elements common to many first year engineering courses, such as literature searching and citation, different engineering disciplines, poster and podium presentations, engineering ethics, and teamwork. But it does so in the context of a simulation of real engineering processes and practices. As such, it covers important supplementary topics that often are not covered in introductory courses such as keeping a design notebook, time management, and interacting professionally with clients and employers.

Preliminary Results and Discussion

In fall 2010, 45 students became virtual interns at *Nephrotex* as part of their first-year introductory engineering course. *Nephrotex* was offered as one of the project-based modules that students signed up for in the course. Other parts of the course introduced students to the different engineering disciplines, how to do research, use the library, etc. Students participated in the internship during a one hour class period either once or twice a week for a total of 10 hours. The class met in a computer lab where each student worked on their own computer. Some students met virtually or in person outside of class to finish assignments or plan for upcoming tasks. Most of the students self-identified as prospective biomedical engineering majors.

Preliminary results include the pre and post interviews that students completed on the first and last days of their virtual internship. The interviews were done through the internship on the computer. We also collected pre and post survey data from all of the students that were enrolled in the introductory course that *Nephrotex* was embedded in ($N = 122$). The surveys were completed online during the first and last weeks of the course. The following aspects of the results will be discussed: the value of teamwork and collaboration as an integral part of the internship experience, the learning gains that students had from pre to post interview, and how the internship helped students understand engineering as a discipline better.

Teamwork and Collaboration

Nephrotex assigns students to one of five teams at the beginning of the game. Each team has five members and is responsible for learning about one of the five materials that the fictitious company is interested in using as a hemodialysis ultrafiltration membrane. Each team has an online design advisor that helps coordinate some group discussions and provides feedback and assistance when they have questions. Some activities in *Nephrotex* are done as individuals and then discussed with a team, while others need to be completed as a team. After going through the first DBT cycle as a team, students are reassigned to new teams using a jigsaw scheme so that each of the five final teams includes one person knowledgeable in each of the five materials. This structure allows each student to be responsible for some amount of content knowledge and forces students to work with different people. This new team completes a second DBT cycle.

On the post interview, when asked about what part of the internship they found most enjoyable, about half of the students (21 out of 45) responded that they enjoyed working in teams and valued the teamwork and group collaboration activities the most.

I enjoyed working with a team; it is fun talk with others who are working on the same thing, and also to bounce ideas off of each other.

I enjoyed the group work most because it allowed all of us to share our ideas and work with each other. It was interesting to hear all the different perspectives and I learned so

much from my teammates. Group work allowed us to make the best decisions and come up with the best device possible to complete our presentation on.

Another set of questions on the pre and post interviews asked about how much they think a career in engineering is associated with different things (such as prestige, healthy work-life balance, innovation/creativity, and working on teams). Working on teams was one of the highest rated items on the list. On a scale of 1 to 4, with 1 being not at all and 4 being a great deal, the average student rating for working on teams was 3.5. Other highly rated items include: opportunities to help other people, opportunities to make the world a better place, and intellectual stimulation (all above 3.5).

Engineering Learning Gains

Although content learning gains were not a major focus of *Nephrotex*, we included pre and post interview questions about some content areas related to the activities of the internship. It was clear in the pre interview that many students did not know very much about the content in the game.

Topics on the pre and post-interview included experimental setup, general design decisions, strategies to prevent membrane fouling, kidney functions, reliability of membranes, diffusion, and hemo-compatibility issues. Students answered two multiple choice and seven short answer content questions on the pre- and post-interviews. These matched-pair questions were analytically coded for each question. Overall, students showed significant gains from pre ($M = 38$) to post ($M = 68$) on these questions ($p < .01$). Two of the questions represent central concepts in the game, (a) setting up an experiment and (b) strategies to prevent membrane fouling, and had the largest significant gains from pre- to post-interview for students. About 30% of students got each question correct on the pre-interview and 70% (question a) and 85% (question b) got the questions correct on the post-interview. Both of these gains were significant ($p < .05$).

While it is encouraging to see students choose the correct answer in a multiple choice scenario, we also asked students to explain their answer in order to see how well they really understood the content (see Table 2). Student 2 in particular learned a lot about this content area, as before the internship he/she was unsure how to answer the question and after he/she gives a detailed and thoughtful response.

Table 2: Explanation of answers to the question about strategies to prevent membrane fouling.

	Pre Interview	Post Interview
Student 1	By giving a patient blood thinners, the blood will be able to filter more easily through smaller openings when clogging becomes a problem.	By adding a charge, such as a negative charge surfactant, this can aid in the reliability and flux rate of the membrane which will reduce fouling and increase flow.
Student 2	I am not sure, but it [carbon nanotube] may allow blood to flow through easier.	Adding a charge to the surfactant will allow particles to flow through the membrane easier. The charge on the membrane will attract or repel the unwanted materials, and this prevents clogging of the pores.

Understanding Engineering

One of the most positive outcomes of the internship is related to how much and in what ways students improved their understanding of the practice of engineering. Not only did most students also report that they would persist in engineering as a career choice, many identified the reason for their persistence as the clearer image of the practice of engineering that was presented in the internship.

I believe it has encouraged my decision to push forward with a career in biomedical engineering. Starting the class I wasn't sure if engineering was right for me anymore, but finishing this internship I believe I could do well in a career in engineering and enjoy it.

This internship with *Nephrotex* has strengthened my enjoyment of biomedical engineering and I feel that I will continue to follow this career path.

On the post survey that the *Nephrotex* students as well as the control students took, there were clear differences in how their views about engineering were changed during the course. The typical response from a *Nephrotex* student was more detailed and discussed more of the different aspects of engineering practice than a typical response from a non-*Nephrotex* (control) student (see Table 3).

Table 3. Course post-survey short answer responses: how has your perception of engineering changed this semester?

Typical Control students	Typical <i>Nephrotex</i> students
Engineering is a lot of math and science but a good engineers can do the math and science but they can also can write and speak coherently too.	The first module really helped me to see how an engineer will maximize and minimize things in a design a prototype and how engineers work together as a team.
There are a lot more engineering disciplines than I was aware of.	I see know how many different solutions there are to a problem and I see how each solution has its benefits and weaknesses. I realize they must decide what is most important when solving a problem.
A lot of engineers work together on projects.	

Although many students came into the course thinking they knew what engineering was, the *Nephrotex* virtual internship gave them a more accurate and grounded view of what engineering is in practice. It is our hypothesis that this more accurate view of engineering, including valuing teamwork, innovation, and creativity, encourages a larger and more diverse pool of candidates to persist in engineering as a career.

Future Work

While analysis is ongoing, our preliminary results point to progress in understanding how students can use a virtual internship such as *Nephrotex* to build and practice the important skills of teamwork and collaboration, gain engineering content knowledge, and envision themselves in the role of an engineer in a realistic practice.

Future work in this area includes coding the discourse generated during *Nephrotex* and analyzing it for the important skills, knowledge, identities, values, and epistemologies that define the field of engineering. Since the game is able to facilitate teamwork and collaboration, we can continue to explore how this process happens. This further analysis will help give us a better picture of how the simulation added to students' views of engineering, how it facilitated teamwork and collaboration within teams, and how the online design advisors were able to help in this process.

References

- Beckett, K. & Shaffer, D. W. (2005). Augmented by reality: The pedagogical praxis of urban planning as a pathway to ecological thinking. *Journal of Educational Computing Research*, 33(1), 31-52.
- Hatfield, D. & Shaffer, D. W. (2006). Press play: Designing an epistemic game engine for journalism. In S. A., Barab, K. E Hay & D. T. Hickey (Eds.), *Learning sciences making a difference: Proceedings of the seventh International Conference of the Learning Sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.
- National Academy of Sciences (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. In Committee on Prospering in the Global Economy of the 21st Century. Washington, D.C.: National Academies Press.
- Rohde, M. & Shaffer, D. W. (2004). Us, ourselves and we: Thoughts about social (self-) categorization. *Association for Computing Machinery (ACM) SigGROUP Bulletin*, 24(3), 19-24.
- Schon, D.A. (1983). *The reflexive practitioner: How professionals think in action*. New York: Basic Books.
- Schon, D.A. (1987). *Educating the reflexive practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.
- Shaffer, D.W. (2004a). Epistemic frames and islands of expertise: Learning from infusion experiences. In Y. Kafai, W. Sandoval, N. Enyedy, A. S. Nixon, & F. Herrera, (Eds.), *Embracing diversity in the learning sciences: Proceedings of the sixth International Conference of the Learning Sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Shaffer, D.W. (2004b). Pedagogical praxis: The professions as models for post-industrial education. *Teachers College Record*, 106(7), 1401-1421.
- Shaffer, D.W. (2005). *Multisubculturalism: Computers and the end of progressive education*. University of Wisconsin-Madison, Wisconsin Center for Education Research.
- Shaffer, D.W. (2006). Epistemic frames for epistemic games. *Computers and Education*, 46(3), 223-234.
- Svarovsky, G. & Shaffer, D. W. (2007). SodaConstructing knowledge through exploratoids. *Journal of Research in Science Teaching*, 44(1), 133-153.

Acknowledgments

This work was funded in part by the MacArthur Foundation and the National Science Foundation through grants REC-0347000, DUE-091934, DRL-0918409, and DRL-0946372. The opinions, findings, and conclusions do not reflect the views of the funding agencies, cooperating institutions, or other individuals.

Designing, Orchestrating and Evaluating Inter-professional Collaboration in a Scripted 3D Learning Space for Vocational Education

Raija Hämäläinen, Kimmo Oksanen, Finnish Institute for Educational Research, Keskussairaalantie 2,
40014 University of Jyväskylä, Finland

Email: raija.h.hamalainen@jyu.fi, kimmo.t.oksanen@jyu.fi

Abstract: Along with the development of new technologies orchestrating CSSL has become a topical issue because new learning spaces challenge the teacher to support collaborative learning in new ways. The aims of the study are twofold. Firstly aim is to design scripted 3D learning space to practice inter-professional knowledge construction in vocational context. Secondly, empirical study aims to refer to the challenge of supporting collaboration in naturalistic, complex 3D learning settings. More specifically, aim is to find out how do groups studying in scripted 3D learning space with (condition 1) and without (condition 2) real-time teacher support differ? The findings of this study indicated that groups studying with real-time teacher orchestration used more effort for providing knowledge (especially explaining one's own situation) and less effort for other inputs (especially off-task talk). This suggests the potential of real-time teacher orchestration for future CSSL.

Introduction

The changing needs of working life create new challenges for both learning and teaching in an educational setting. Work tasks have become increasingly complicated and, typically, work is based on inter-professional expertise and the shared construction of new knowledge (Billett, 2008). In traditional vocational school settings, however, students of different fields do not work together to solve problems. As vocational jobs are likely to call for collaboration in the future, it is necessary to find new ways of supporting collaboration in vocational learning. One way to respond to these needs is to create new technology-enhanced learning (TEL) spaces that offer added incentive to practice inter-professional collaboration. During the last years, TEL environments have rapidly improved through the social media, 3D spaces (e.g. Second Life) and games for learning. Thus, technology can be utilized to enhance collaboration in learning and working practices, for example, by offering more illustrative spaces to practice inter-professional work, thus eliminating the danger in work safety compared to traditional methods (Hämäläinen, Oksanen & Häkkinen, 2008). Despite these optimistic notions of new TEL spaces meeting the needs of inter-professional working life, systematic empirical CSSL research in vocational contexts has so far been dealt with less than, for example, learning in the higher education context.

Many researchers have reported the beneficial effects of computer-supported collaborative learning (CSSL) (e.g. De Wever et al., 2010). The potential of CSSL is widely agreed, because through joint construction of shared understanding, meaning, knowledge and expertise, a group can create something that exceeds what any one individual could achieve (Stahl, 2004). However, in practice, the "ideal" high level and productive collaboration is relatively rare and is challenging to "create" in technology-enhanced school settings (Kollar, 2010; Hämäläinen, 2011), thus the problems with collaborative group work (Järvelä et al., 2010). Thus, in authentic learning contexts, totally free collaboration does not necessarily promote productive collaboration or high-level learning. Previous research has focused on collaboration scripts as a particular kind of instructional approach to support CSSL, typically without real-time support of the teacher (Kobbe, Weinberger, Dillenbourg, Harrer, Hämäläinen, Häkkinen & Fischer, 2007). Recent critical studies have suggested that focusing only on specific scripts reduces—or even negates—the role of teachers in supporting collaboration (Dillenbourg & Jermann, 2010; Hämäläinen & Häkkinen, 2010). Along with the development of scripts, it is necessary to pay attention to the effective and flexible use of the potential offered by future learning spaces with regard to more active role of the teacher.

Recently, flexible orchestration (based on research findings) has widely been suggested as a solution for arranging collaboration in naturalistic learning situations (e.g. Dillenbourg, et al., 2009; Kollar, 2010). As such, the concept of orchestrated learning is not new (Brown, 1992); along with the development of new technologies (e.g. 3D spaces), orchestrating has again become a topical issue because new learning spaces challenge the teacher to support collaborative learning in new ways. Orchestrating CSSL highlights the balance between the instructions and "free collaboration processes" as well as contextual nature of collaboration. However, this does not mean "totally free" intuitive teaching (without educational goals). A common feature of orchestrating CSSL is that it draws systematically on research-based productive collaborative learning situations in the design and real-time implementation of teaching. The main idea is to combine the design and the improvisation. The curriculum sets the starting points for activities, the environment supports collaboration, the teacher designs and orchestrates the structure for learning processes (based on research findings of

productive collaboration; e.g. solving cognitive conflicts) and the learners are then given a certain freedom for shared knowledge construction. During the collaborative learning situation, the teacher simultaneously designs, monitors and supports learning processes during group work based on contextual needs. This study supplements research on collaboration scripts by teachers, timely orchestration in future TEL space (e.g. Dillenbourg, Järvelä & Fisher, 2009). The aims of the study are twofold. Firstly aim is to design scripted 3D learning space to practice inter-professional knowledge construction in vocational context. Secondly, aim of empirical study is to refer to the challenge of supporting collaboration in naturalistic, complex 3D learning settings. More specifically, aim is to find out what kind of effects do *real-time teacher orchestrations* have on processes of collaborative knowledge construction? To find out this we seek whether groups studying in scripted 3D learning space with (condition 1) or without (condition 2) real-time teacher support differ in knowledge construction.

Research question: How do groups studying in scripted 3D learning space with (condition 1) and without (condition 2) real-time teacher support differ?

Scripted 3D Learning Space

In this study 3D online learning space (see Figures 1 & 2) for groups of five participants at the time with scripted tasks (see Kobbe et al., 2007) was developed. The aim is to enhance the inter-professional knowledge construction in the area of human sustainability. The learning space is based on RealXtend Technology (Open Source Platform for interconnected virtual worlds <http://www.realxtend.org/>). In a 3D space participants work as volunteer staff at a charity concert and are supposed to make sure that customers are satisfied and that everything is ready for the gig. To achieve this, participants solve inter-professional puzzles. The environment provides each participant a first-person-view into the 3D space. Participants are connected to each other via a server, which runs the virtual world in which all the action occurs. The space can be used with PC which has a network connection and human-to-human communication is supported by a chat and VoIP speech system. 3D space includes three scripted collaborative tasks (with supplementing inter-professional roles) that require effort and commitment from several students for successful completion. Next in Table 1 the main ideas of scripted tasks with theoretical groundings of collaboration are described.



Figures 1 & 2. 3D Learning Space.

Table 1: Brief description of scripted tasks.

	Description	Key points (Pedagogical idea)
Gate	Groups need to open a gate to the festival area by entering a password to the electronic lock in the correct order. Every student has gotten their own part.	Coordination: dependency between group members and control of an aggregate of individuals (Barron 2000).
Restaurant	Groups are supposed to keep customers satisfied by serving them in the restaurant area. Students have supplementing inter-professional roles. The roles are: cook, waitress, receptionist and serviceman. Every role has his/her own responsibility area and students are supposed to integrate and synchronize those tasks together. At the end of the task band members comes to the restaurant to have lunch. One band member has a nut allergy, but he still wants to have a portion which usually includes nuts. Group need to find out the allergy and serve the right portion without.	Distributed expertise, mutual dependency and integration of solo – group activities: dependency between participants is created by the different knowledge and resources distributed to each of the learners (Price et al. 2003) leading to personal responsibility, shared knowledge construction and need to combine different professions.
Stage	The groups' task is to identify each band member by combining received tips. Each student receives own tips, and players need to recognize who is who of the band members. In this way, players are able to organize the band's stuff in the right place on the stage.	Cognitive conflict: A situation is created by having different learners receive different information at the same time, but without proper co-ordination, causing an unsolvable problem (Moscovici and Doise, 1994).

Method

The main interest of this study is in the effect on the processes of designing (with and without real-time teacher orchestration) collaboration in vocational learning settings. The empirical study was conducted in an authentic classroom setting (cameras and recording systems were used). In spring 2010, 18 vocational students and two teachers (four groups of five persons) participated in the study. The experiment included a two-to-three hour working period in a scripted 3D learning space at the College of Jyväskylä, Finland. Data were gathered by using observational notes on the sessions as well as by videotaping and recording the groups' discussions (6016 transcribed utterances). The aim of the study is to deepen the understanding of the relationship between scripting with (condition 1) or without (condition 2) real-time teacher orchestration and productive knowledge-construction. More specifically, the study compared shared knowledge construction within different scripted 3D-learning conditions (with and without real-time teacher orchestration).

This approach is derived from the methodological development of our earlier studies (e.g. Hämäläinen, 2010; Hämäläinen et al., 2008). After the experiment, all video data were transcribed (four groups with a total of 6016 utterances), and discussion entries were read through several times. Then, all the data were verified: videos were watched, observations were rechecked and transcribed utterances were re-examined (at this stage, 5386 of 6016 utterances were categorised to include activities of shared knowledge-construction). As our earlier studies (Hämäläinen et al., 2008) have indicated that faster groups do better in their final test results than the slower playing ones, we compared the time used in the game with and without teacher orchestrating collaboration activities. To evaluate whether groups engaged in high-level knowledge construction and how different collaboration settings differed, two types of content analysis were conducted (unit of analysis=utterance). The analysis used quantitative and qualitative content analyses to focus on the group knowledge-construction processes (Berelson, 1952). Five thousand three hundred and eighty-six utterances were categorized into six main categories ("providing knowledge", "contextual questions", "shared problem solving", "management of interaction", "summing up/discovering solution" and "other inputs"). Then, to find qualitative differences within the knowledge-construction processes, the utterances were sorted further into 25 different data-driven subcategories (see table 2 in the result section for more details). Regarding the quantitative content analysis, the aim was to describe whether shared knowledge construction in two different research settings would be dissimilar, while the aim of the qualitative content analysis was to develop understanding how real-time teachers' activities enhance high-level knowledge construction.

Results

In orchestrated learning setting the learning session lasted an average of approximately 1 hour 58 minutes, while with the groups without orchestration the session lasted an average of 2 hours 31 minutes. Between the groups studying with (2405 utterances) and those studying without (2981 utterances) a real-time teacher's orchestration, the findings indicated two main differences in knowledge-construction activities in the categories "providing knowledge" and "other inputs" (see Table 2). More specifically, in providing knowledge, both groups brought in new information, gave technical and contextual advices to group members and stated their (non-justified) opinions. Thus, neither of groups did not use justified opinions. However, groups with teacher orchestration used 18 percent of their utterances for explaining their own situation, while groups without teacher orchestration only used 5.9 percent of their utterances for this (see, Table 2). The other main difference concerned the amount of other inputs; especially off-task talks. Groups without teacher orchestration used 36.1 percent (1077 utterances, of which 452 off task) of their utterances for other inputs, while groups with teacher orchestration used 13 percent (315 utterances, of which 35 off task) of their utterances for this (see Table 2).

Table 2: Main differences between the groups with and without real-time teacher orchestration.

	Groups with orchestration		Groups without orchestration without		
Providing knowledge	1003	41,7 %	726	24 %	%
Piece of advice – contextual	162		161		5,4 %
Piece of advice – technical	5		11		0,4 %
New information	380		332		11,1 %
Explaining own situation	428		177		5,9 %
Justified opinion	0		0		0 %
Non- justified opinion	29		45		1,5 %
Contextual questions	309	12,8 %	349	11,7 %	
New openings	37		31		1,0 %
Technical	13		14		0,5 %
Specifying	158		229		7,7 %
Reasoning	6		8		0,3 %
Opinion	95		67		2,2 %

Shared problem solving	520	21,6 %		616	20,7 %	
Carry on with one's work	152		6,3 %	240		8,1 %
Answers	286		11,9 %	315		10,6 %
Disagrees / argues	64		2,7 %	47		1,6 %
Reasoning	18		0,7 %	14		0,5 %
Management of Interaction	184	7,7 %		157	5,3 %	
Group organization	54		2,2 %	59		2,0 %
Planning upcoming activity	19		0,8 %	11		0,4 %
Organizational questions	109		4,5 %	81		2,7 %
Support	2			6		
Summing-up / discover solution	71	3,0 %		56	1,9 %	
Based on group activities	59		2,5 %	48		1,6 %
Based on own actions	2		0,1 %	1		0 %
Based on unknown reason	10		0,4 %	7		0,2 %
Other Inputs	315	13,1 %		1077	36,1 %	
Other Inputs – related to game	273		11,4 %	477		16 %
Describing technical problems	7		0,3 %	148		5 %
Off task - Not related to game	35		1,5 %	452		15,2 %
	2405 utterances	100 %	100 %	2981 utterances	100 %	100 %

Discussion

Recent critical studies has indicated several reasons for failure in collaborative learning, such as a lack of teachers to orchestrate learning processes (Arvaja, Hämäläinen & Rasku-Puttonen, 2009), uneven work division (e.g. free riding) (Strijbos & De Laat, 2010), individual working methods of group members (Hämäläinen & Häkkinen, 2010) and inappropriate use of external (e.g. texts, learning tools; Jeong, & Hmelo-Silver, 2010) and internal learning resources (e.g. prior knowledge, Arvaja, 2007). Thus, there is an evident need to highlight the role of the teacher in enhancing productive collaboration. At their best, technological environments can offer new learning spaces for knowledge construction and help teacher to orchestrate and to monitor learning activities and to support collaborative knowledge construction within different groups. However, there are many unrealistic expectations connected to role of technology. Firstly, very rarely, the tools or environments that are available to support learning are designed with pedagogical or instructional theories of learning and teaching in mind (Laurillard, 2009) and therefore the technologies itself do not typically guarantee collaboration within groups (Bluemink, Hämäläinen Manninen & Järvelä 2010). Secondly, even the technological environments itself are designed to support collaboration there are several challenges on computer-supported collaborative pedagogies, as no technology alone can replace the teacher in supporting creative collaboration processes (Littleton, 2009). Wegerif (2006) has even argued that some of underlying assumptions behind CSCL pedagogies are mainly based on industrial age and focus too much on individual's knowledge and skills.

To develop pedagogical approaches to really meet the needs of CSCL orchestrating learning must be both pedagogically structured (based on learning theories) and also flexible to reach the learning goals. Thus, the learning goal (and task of which the goal is striven for) itself and contextual needs sets the limits to how much learning should be designed and instructed (Hämäläinen & Häkkinen, 2010). The precondition for orchestrating collaboration is the understanding of collaboration processes and the reasons for the differences in the knowledge-construction processes. This study indicated that groups studying with real-time teacher orchestration used more effort for providing knowledge (especially explaining one's own situation) and less effort for other inputs (especially off-task talk). Thus, scripted 3D space itself gave guidance and help in task solving. However, a teacher's professional competencies were helpful, especially for reducing off task discussions in 3D space and for understanding the inter-professional nature of the task. This suggests the potential of real-time teacher orchestration as explaining one's own situation is highly related to inter-professional work and practicing that is one way to respond to the changing needs of the future of people's work lives. Thus, the findings are in line with the notion that real-time teacher orchestration is suited to collaborative learning (Dillenbourg et al., 2009). To conclude, future research needs to focus further on how to support collaborative learning with both technology and human guidance.

References

- Arvaja, M. (2007). Contextual perspective in analysing collaborative knowledge construction of two small groups in web-based discussion. *International Journal of Computer-Supported Collaborative Learning*, 2(2/3), 133-158.

- Arvaja, M., Hämäläinen, R., & Rasku-Puttonen, H. (2009). Challenges for the teacher's role in promoting productive knowledge construction in computer-supported collaborative learning contexts. In J. O. Lindberg & A. D. Olofsson (Eds.) *Online Learning Communities and Teacher Professional Development: Methods for Improved Education Delivery*. Hersey: IGI Global, 263-280.
- Barron, B. (2000). Achieving coordination in collaborative problem solving groups. *The Journal of the Learning Sciences*, 9(4), 403-436.
- Berelson, B., (1952). *Content analysis in communication research*. Glencoe, IL: Free Press.
- Billett, S., (2008). The workplace as learning environment: Introduction. *International Journal of Educational Research*, 47 (4), 209-212.
- Bluemink, J., Hämäläinen, R., Manninen, T., & Järvelä, S. (2010, in press.). Group-level analysis on multiplayer-game collaboration: How do the individuals shape the group interaction? *Journal of Interactive Learning Environments*. doi:10.1080/10494820802602444
- Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of Learning Sciences*, 2(2), 141-178.
- De Wever, B., Van Keer, H., Schellens, T., & Valcke, M. (2010). Structuring asynchronous discussion groups: Comparing scripting by assigning roles with regulation by cross-age peer tutors. *Learning and Instruction*, 20(5), 349-360.
- Dillenbourg, P., & Jermann, P. (2010). Technology for Classroom Orchestration. In M. S. Khine and I. M. Saleh, (Eds.). *New Science of Learning*. Springer Science+Business Media, New York, 525-552.
- Dillenbourg P., Järvelä S. & Fisher F. (2009). The evolution of research on computer-supported collaborative learning: From design to orchestration. In Balacheff, N., Ludvigsen, S., de Jong, T., Lazonder, T.A. & Barnes, S. (Eds.). *Technology Enhanced Learning: Principles and Products*. Springer, Netherlands, 3-19.
- Hämäläinen, R. (2011, in press). Using a game environment to foster collaborative learning: a design-based study. *Technology, Pedagogy and Education*, 20(1), (45-62).
- Hämäläinen, R. & Häkkinen, P. (2010). Teachers' instructional planning for computer-supported collaborative learning: Macro-scripts as a pedagogical method to facilitate collaborative learning. *Teaching and Teacher Education*, 26(4), (871-877).
- Hämäläinen, R., Oksanen, K. & Häkkinen, P. (2008). Designing and analyzing collaboration in a scripted game for vocational education. *Computers in Human Behavior*, 24(6), (2496-2506).
- Jeong, H., & Hmelo-Silver, C.E. (2010). Productive use of learning resources in an online problem-based learning environment, *Computers in Human Behavior*, 26(1), 84-99.
- Järvelä, S., Volet, S. & Järvenoja, H. (2010). Research on Motivation in Collaborative Learning: Moving beyond the cognitive-situative divide and combining individual and social processes. *Educational Psychologist*, 45 (1), 15-27.
- Kobbe L., Weinberger A., Dillenbourg P., Harrer A., Hämäläinen R., Häkkinen P. et al. (2007). Specifying computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning* 2(2/3), 211-224.
- Kollar, I. (2010). Turning the classroom of the future into the classroom of the present. In K. Mäkitalo-Siegl, J. Zottmann, F. Kaplan & F. Fischer (Eds.), *The Classroom of the Future: Orchestrating collaborative learning spaces*. (pp. 245-255). Rotterdam: Sense.
- Laurillard, D.M. (2009). The pedagogical challenges to collaborative technologies. *International Journal of Computer-Supported Collaborative Learning*, 4(1), 5-20.
- Littleton, K. (2009, August). Communication, collaboration and creativity: How musicians negotiate a collective 'sound', paper presented at the 13th biennial EARLI conference, the Netherlands.
- Moscovici, S., and Doise, W. (1994). *Conflict and Consensus: A General Theory of Collective Decisions*. London: Sage Publications.
- Price, S., Rogers, Y., Stanton, D., & Smith, H. (2003) A new conceptual framework for CSCL: Supporting diverse forms of reflection through multiple interactions. In (Eds.), B. Wasson, S. Ludvigsen, U. Hoppe, *Designing for Change in Networked Learning Environments. Proceedings of the International Conference on Computer Support for Collaborative Learning 2003*, (pp. 513 – 523). Bergen: InterMedia.
- Stahl, G. (2004). Building collaborative knowing. Elements of a social theory of CSCL. In P. Dillenbourg (Series Ed.) & J. W. Strijbos, P. A. Kirschner & R. L. Martens (Vol. Eds.), *Computer-Supported Collaborative Learning, Vol. 3. What We Know about CSCL... and Implementing It in Higher Education*. Boston, MA: Kluwer Academic Publishers, 53-85.
- Strijbos, J. W., & De Laat, M. F. (2010). Developing the role concept for computer-supported collaborative learning: An explorative synthesis. *Computers in Human Behavior*, 26, 495-505.
- Wegerif, R. (2006). A dialogical understanding of the relationship between CSCL and teaching thinking skills. *International Journal of Computer-Supported Collaborative Learning (ijCSCL)*, 1 (1), 143-157.

Learning with Prediction Markets: An Experimental Study

Cali Mortenson Ellis, University of Michigan Departments of Political Science and Public Policy, 5700 Haven Hall, 505 South State Street, Ann Arbor, MI, 48109-1045, cmortens@umich.edu
Rahul Sami, University of Michigan School of Information, North Quad, 105 S. State St, Ann Arbor, MI 48109, rsami@umich.edu

Abstract: Prediction markets are designed to aggregate the information of many individuals in order to forecast future events. These markets provide participants with an incentive to seek information and a forum for interaction, making them a promising tool to motivate student learning. We carried out a quasi-experiment in an introductory political science class to study the effect of prediction markets on student engagement. While we found no significant improvement in students' enthusiasm or extent of topical reading, we did find that those already reading broadly at the course start were more likely to trade actively in the markets. These findings indicate that prediction markets may be most successful as an education tool in settings where individuals are already knowledgeable about the topics of the market.

Introduction

Prediction markets (also known as information or decision markets) are designed to aggregate the information of many individuals in order to forecast future events. Such markets have been used in a variety of contexts; for example, the Iowa Electronic Market forecasts political and economic events, and the Hollywood Stock Exchange (*hsx.com*) forecasts movie box-office performance (Wolfers and Zitzewitz, 2004). The rationale behind using markets for forecasting is that traders reveal some information to each other through their trades, and learn from others' trading behavior, and thus, the market price reflects the combined information available to all traders. In this paper, we report on a quasi-experimental study of the use of prediction markets as a pedagogical tool to augment classroom learning.

Prediction markets have been used as classroom learning tools in keeping with a larger trend in education toward including interactive and technological resources into the classroom setting. Abramson (2010), for example, used prices posted on *inTrade.com* with upper-level undergraduates to illustrate American campaign strategies in the last Presidential election. Among the key advantages of prediction markets, researchers have noted that they provide incentives to motivate traders to "ferret out accurate information" and "not amplify individual errors, but eliminate them" (Sunstein, 2006). These strengths align well with our goals as instructors: we want to train our students to search for relevant information, and to critically analyze received information. Prediction markets also potentially provide a unique forum for cooperative learning, as they allow students to communicate with each other indirectly through market prices. Thus, students who may be unresponsive to face-to-face cooperative learning projects, such as classroom discussions or team assignments, may be still be able to collaborate and learn through the anonymous structure of the market interface.

The rest of this paper is structured as follows: In Section 2, we describe our experimental methodology. We explain the market structure and interface used in Section 3. We present descriptive statistics of our student population in Section 4. Section 5 reports on our data analysis procedures and the results of this analysis. In Section 6, we discuss the insights yielded by this analysis and the limitations of this study, as well as potential areas of further research.

Methodology

We employed a nonequivalent comparison group design, a quasi-experimental design using both control groups and pretests, as per Shadish, Cook and Campbell (2002). Students were randomized over the entire class into treatment (trader) and control (non-trader) groups. At the start of the semester, we administered a pre-test survey, pre-test knowledge quiz, and statement of informed consent to each student. We explained the purpose of the research and provided a live demonstration of the market interface using a simple example market. At the end of the semester, all students were also provided with a post-test survey and post-test knowledge quiz. Surveys and quizzes were administered in class, on paper in order to ensure a greater level of participation than can occur with web-based surveys. We also developed an extra credit question for one of the midterm exams. In order to ensure fairness and address potential concerns about diffusion, both treatment and control groups were given access to view the markets via the experimental website. However, only the treated group could trade in the market for cash prizes. We also relied on regular email communication with students to encourage them to trade in the markets. We report results for the 129 students for whom we collected complete information.

Market Topics

Prediction markets by definition are about current events with future uncertainty. We therefore created twelve markets with topics that fit the content of an introductory world politics course. We attempted to select a range of topics of interest to a variety of students, including whether Israel would announce a settlement freeze, if the elections in Haiti would take place as scheduled, and whether Google would cease all operations in China.

Market Structure and Interface

We used Zocalo, an open-source software package for running prediction markets, for our market deployment. We built a simplified custom user interface for these markets using the Drupal open source application platform. Students could see a news feed consisting of recent headlines relevant to the market; clicking on a headline led to the article on a newspaper website. We also included a place for students to leave comments and see comments by other students. Students could access the website at any time through university's secure portal.

Treated students received a budget of \$1000 virtual dollars (equivalent to US\$10 in real cash) at the start of the semester. For each of the market topics, there were two securities: a "yes" security that eventually paid off one virtual dollar if the event happened, and a "no" security that eventually paid if the event did not happen. Each market had a closing date which could be either the date of the supposed future event (for example, elections in Haiti which were scheduled to be held on February 28, 2010), a date in the middle of the term chosen by the researchers, or the end of the term. It was important to have some markets close in the middle of the term, as the students' correct predictions in such a market could generate additional points to be used for trading in another market. Students could use their point balances to buy or sell shares of either "yes" or "no" for the event in order to drive the price to a point that they thought was correct. For simplicity, we gave students the option of buying and selling shares in blocks of 10 or 100 units.

Students did not directly trade securities with each other; instead, an (automated) market maker bought securities from students who wanted to sell, and sold securities to students who wanted to buy. The market maker quotes a price at each point in time, and adjusts the prices for each unit bought or sold (Hanson, 2003).

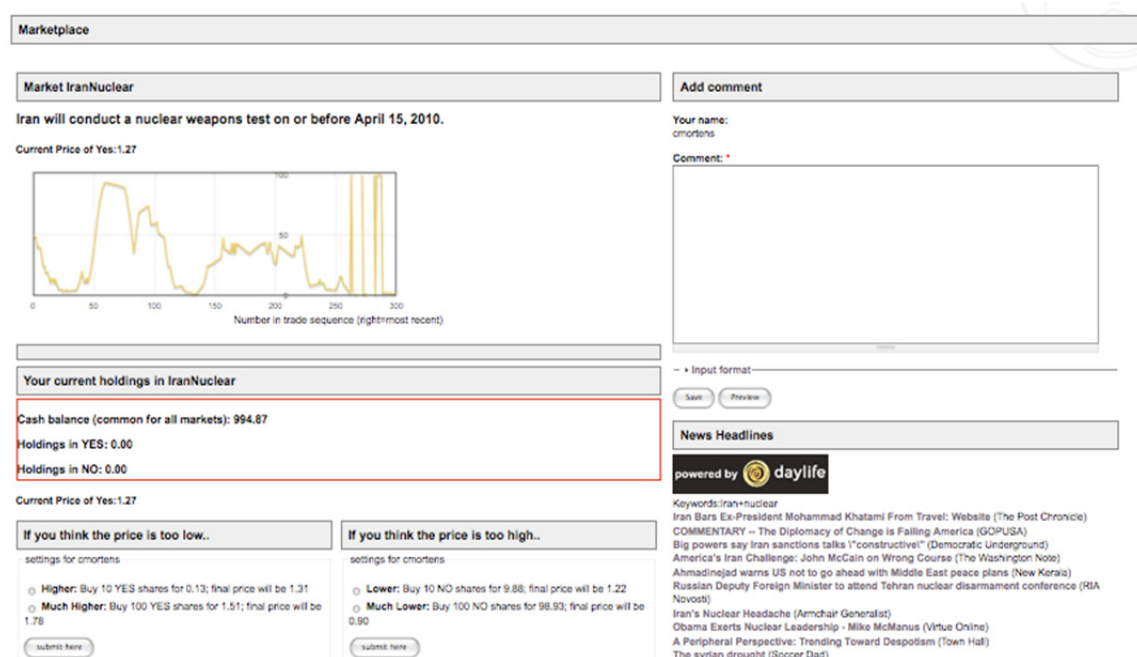


Figure 1. Screenshot of Market Interface.

Descriptive Statistics from Initial Knowledge Quiz and Survey

For this section on descriptive statistics, we report values for the overall population of the study, together with results of two-tailed t-tests with an assumption of unequal variances and the Satterthwaite approximation of degrees of freedom for mean differences between trader (treatment) and non-trader (control) groups. We use an α of 0.05 as the significance level for all of our statistical tests.

Survey Questions on Dependent Variables of Interest

Students filled out surveys that elicited information about their background, enthusiasm for the course topic, and sources they relied on for news. Our key dependent variables of interest pertained to enthusiasm, outside

reading, and general knowledge of world politics. Using a 7-point Likert scale to measure student's enthusiasm for world politics, we found an initial average score of 5.6202 ($|t|=0.076$, $p=0.94$, $d=0.01$), corresponding to a point between "slightly enthusiastic" and "fairly enthusiastic." We asked if students read news about the politics of other countries at least once a week in a newspaper or on the internet. Almost 70 percent of students indicated that they did ($|t|=0.86$, $p=0.39$, $d=0.15$), which may indicate a selection effect for students who elect this course in the first place. The quiz was the final component of interest, measuring actual knowledge about the market topics of the experiment. Examples of quiz questions include, "Iran has conducted a nuclear weapons test within the past year" and "The current Prime Minister of Japan promised the nation that he would soon visit The Yasukuni Shrine." The mean percent correct answers was 32.2 and there was no significant difference in mean performance between the control and treatment groups ($|t|=1.29$, $p=0.20$, $d=0.23$).

MSLQ Survey Questions - Cognitive and Meta-cognitive Strategies

In order to control for the effect of intrinsic motivation, we administered a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ, from Pintrich *et al.*, 1993), specifically the section, "Cognitive and meta-cognitive strategies: self-regulation." This section includes questions such as, "When reading for a course, I make up questions to help focus my reading." These scores are demonstrably correlated with higher course grades (Pintrich *et al.*, 1993). For each question, students are asked to rate on a 7-point Likert scale how much the statement applies to them. We hoped that higher scores on this section indicate students who may be more willing to take the extra steps necessary to ensure they thoroughly understand the subject matter. The mean score on the MLSQ was 3.684 ($|t|=0.39$, $p=0.69$, $d=-0.07$).

Results

In this section, we present results on the effect of student exposure, obtained by comparing the initial and final surveys and knowledge quizzes of control and treatment group. Our original hypothesis was that participation in prediction markets would increase enthusiasm for and knowledge of the subject matter of an undergraduate political science course. Therefore, we expected to see improvements among traders in our primary dependent variables of interest: enthusiasm, outside reading and knowledge.

Table 1: Improvement in key dependent variables over one semester.

Question - Changes from start to end surveys	Non-Traders Start	Non-Traders End	Non-Traders Difference	Traders Start	Traders End	Traders Difference	Diff-in-Diff (Trader-Nontrader)
How interested are you in world politics? (1, completely unenthusiastic - 6, completely enthusiastic)	5.63	5.29	-0.34 ($ t =1.80$, $p=0.077$, $d=-0.45$)	5.61	4.97	-0.64* ($ t =3.10$, $p=0.003$, $d=-0.76$)	-0.30 ($ t =0.079$, $p=0.94$, $d=-0.01$)
Do you read news about the politics of other countries at least once a week in a newspaper or on the internet?	0.661	0.742	0.081 ($ t =1.29$, $p=0.20$, $d=0.33$)	0.731	0.806	0.075 ($ t =1.69$, $p=0.096$, $d=0.41$)	-0.006 ($ t =1.08$, $p=0.28$, $d=-0.19$)
Quiz Scores (mean percent correct answers)	0.303	0.354	0.051* ($ t =2.19$, $p=0.05$, $d=0.90$)	0.338	0.394	0.056 ($ t =4.67$, $p=.056$, $d=0.79$)	-0.005 ($ t =0.21$, $p=0.83$, $d=-0.04$)

Unfortunately, our results did not bear out our original hypothesis, as both groups of students reported lower levels of enthusiasm for the subject of the course, and students in the treatment group reported even less enthusiasm than the control group. We were not surprised to see a drop in enthusiasm given the timing of the end of semester survey shortly before the final exam. The first six columns of Table 1 report the results of a within-group paired t-test. Specifically, we test the null hypothesis that the difference between the measure from the beginning to the end of the semester is equivalent to zero. The last column of this table shows the differences between the change in means. This difference-in-difference between traders and non-traders was not significant for any of the key dependent variables, meaning that although some of the changes from the beginning to end of the semester were significant for each group, the changes in levels between traders and non-traders was not. Nonetheless, the greater drop in enthusiasm among traders is surprising and led us to seek a finer-grained perspective on the trader group.

Indicators of Active Trading

In this section, we report results only for students in the treatment group (traders), differentiating between *active* and *inactive* traders. Active traders (N = 45) are defined as those who logged in and executed at least one trade, as was required to receive the cash payment. Inactive traders (N = 22) are those in the treatment group who never logged in. Among the 42 students with multiple trades, the mean number of trades was 8.18. (We count multiple trading actions by a trader in the same market within one minute as a single trade.) In this section, we report differences between active and inactive traders in parentheses unless otherwise indicated.

Active traders had insignificantly higher MSLQ (3.77) scores than did inactive traders (3.40) ($|t|=1.50$, $p=0.14$, $d=0.39$), and their score was comparable to the mean for the control group (3.72). Recall that the MSLQ locates students who are more likely to, “use more deep-processing strategies such as elaboration and organization and who attempt to control their cognition and behavior through the use of metacognitive planning, monitoring, and regulating strategies” (Duncan and MacKeachie, 2005). It is possible that participation in the prediction markets was seen as an additional metacognitive strategy used to supplement course preparation.

Another notable finding among active traders is that they had a significantly higher prior level of reading in the area. At the start of the semester, 82 percent of those students who would eventually become active traders reported reading about the politics of other countries at least once per week. By comparison, only 54 percent of inactive traders reported such reading ($|t|=2.25$, $p=0.031$, $d=0.83$). In other words, the students who were already reading broadly at the start of the course were more likely to trade actively in the market. By the end of the semester, only inactive traders exhibited a statistically significant improvement of 18 percent on this measure. Active traders improved their reading by 7 percent, which is significant at the $\alpha = 0.1$ level, and remained ahead of other groups, with 84 percent reporting this activity by the end of the term. There was no statistically significant difference in improvement between active and inactive traders or traders and non-traders.

Table 2: Reading about the politics of other countries at least once per week (active vs. inactive traders).

	Semester Start	Semester End	Difference (Start-End) within-group t-test
Active Traders	0.822	0.844	0.0222 ($ t = 0.443$, $p = 0.66$, $d=0.13$)
Inactive Traders	0.545	0.727	0.1818* ($ t = 2.16$, $p = 0.042$, $d=0.92$)
<i>Difference</i> (Active-Inactive) independent 2- group t-test with unequal variance	0.277* ($ t =2.25$ $p=0.031$, $d=0.83$)	0.117 ($ t =1.05$ $p=0.30$, $d=0.37$)	-0.1596 ($ t = 1.63$, $p=0.11$, $d=-0.57$)

Table 3: Improvement in knowledge quiz scores by group (active vs. inactive traders).

	Start Quiz Score	End Quiz Score	Difference (Start-End) within-group t-test
Active Traders	0.329	0.387	.0572* ($ t = 2.67$, $p = 0.011$, $d=0.79$)
Inactive Traders	0.354	0.407	.0532 ($ t = 1.75$, $p = 0.095$, $d=0.74$)
<i>Difference</i> (Active – Inactive) independent 2-group t- test with unequal variance	-0.024	-0.020	-.00397 ($ t = 0.107$, $p = 0.92$, $d=0.036$)

We next looked at the performance on the quiz score (Table 3). Active traders showed slightly greater progress on this measure, increasing from 32.96% to 38.68%, a statistically significant 5.72% improvement. These results taken together indicate that the prediction markets may have some value in improving content learning for students who are motivated by the instrument, but further experiments are needed to investigate the extent to which they enable learning beyond the specific topics of the markets they trade in.

Motivations and Behavior of Active Traders

The following section only reports findings for students in the group of active traders (N=45), defined as those who logged in and executed one or more trades. We wanted to know if students discussed prediction markets or the topics of the markets outside class, an indirect indicator of collaborative learning. 31% of traders reported discussing the market topics with friends or family and 24% reported discussing the prediction markets experiment itself with other classmates. 80% found the experiment relevant to the topic of the course.

We asked active traders if the experiment encouraged them to read about the *market topics* outside of class. 51% reported reading more about the Google/China dispute, and 40% reported reading more about the Olympics. Only 11% reported reading about the military or Palestinian elections, and 9% reported reading about the elections in Haiti. Overall, there was some evidence that the markets prompted additional reading, but that it was not distributed evenly across all the topics. This is consistent with the original design of our experiment, where we attempted to provide markets on a range of topics to accommodate different interests.

We also asked students how they made their trading decisions. Fifty-eight percent stated that trading decisions were made “based on personal beliefs,” followed by 51% based on news reports. The smallest number of students decided based on the outcome they wanted (4 percent) or the trades of others (i.e. the price reported on the graph – 6 percent). Forty percent of students believed that their predictions were more correct than those of their classmates. This is in line with the claim by Sunstein (2006) that market trading encourages individual information processing and reporting, rather than groupthink or herd behavior.

Conclusion

As Whitton (2010) warns, not all students will be responsive to interactive technological projects such as prediction markets. One of our most striking findings is that active traders had a significantly higher prior level of reading than other students in the topics of the markets, outside of their course requirements, both at the beginning and end of the semesters. Another is their higher level of MLSQ characteristics, indicating students who have more self-regulated study habits. The students who did actively trade reported that they enjoyed doing so, and that it prompted them to read more widely on some of the market topics. These findings together hint that prediction markets may be best deployed in a classroom of students who are highly motivated and already engaged in the subject matter. An elective upper-level undergraduate course or a graduate course may be more appropriate settings for using prediction markets as an educational tool. Our experiment also provides some guidance on the design of a prediction market interface: The feedback we received from traders also suggests that it is useful to integrate news feeds with the market.

For reasons of fairness in our randomized study, we chose a controlled set of market topics that were outside of the specific topics studied in the class. One unanswered question from our research involves how students would interact with a decision market which is more closely connected to their interests. For example, it is possible to design the interface so that students can create markets based on their own interests in certain topics of a class. We asked students directly if they had the opportunity to create their own market on any topic (for example, who will win the NCAA championships), if they would do so, and 44 percent stated that they would. It would also be interesting to conduct a future study with markets linked to the course syllabus, for verification of whether more immediacy in the market topics would pay off in learning gains.

References

- Abramson, P. (2010). Using Intrade.com to Teach Campaign Strategies in the 2008 U.S. Presidential Election. *PS: Political Science & Politics*, 43:139-144.
- Duncan, T. G. & McKeachie, W.J. (2005). The Making of the Motivated Strategies for Learning Questionnaire. *Educational Psychologist*, 40(2): 117-128.
- Hanson, R. (2003) Combinatorial Information Market Design. *Information Systems Frontiers*, 5(1): 107–119.
- Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1993). Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, 53(3):801-813.
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton-Mifflin.
- Sunstein, C. R. (2006). Deliberating Groups versus Prediction Markets (or Hayek's Challenge to Habermas). *Episteme: A Journal of Social Epistemology*, 3.3: 192-213.
- Whitton, N. (2007). Motivation and computer game based learning. In *ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007*. Available at <http://www.ascilite.org.au/conferences/singapore07/procs/whitton.pdf>
- Wolfers, J. & Zitzewitz, E. (2004). Prediction Markets. *Journal of Economic Perspectives*, 18(2): 107-126.

Acknowledgements

This research was partially supported by the National Science Foundation under grant CCF-0728768. We are very grateful to Allan Stam for supporting these experiments in his courses; Skip Lupia, Stephanie Teasley, Kara Makara, and Rick Wilson for numerous helpful suggestions and feedback; Stan Dimitrov for assistance with the market interface; and Mohammed Hadhrawi, Yung-Ju Chang, and Yi-Chin Wu for useful discussions on an earlier project. This work was examined by the Institutional Review Board of the University of Michigan.

Co-design of Collaborative Collective Knowledge Environment

Elizabeth S. Charles, Dawson College, 3040 de Maisonneuve W., Mtl., Canada, echarles@dawsoncollege.qc.ca

Mike Tissenbaum, University of Toronto, 252 Bloor Street W. Toronto, Canada, mike.tissenbaum@utoronto.ca

Chris Whittaker, Dawson College, 3040 de Maisonneuve, Mtl., Canada, cwhittaker@dawsoncollege.qc.ca

Michelle Lui, University of Toronto, 252 Bloor Street W. Toronto, Canada, michelle.lui@utoronto.ca

Michael Dugdale, John Abbott College, 21275 Rue Lakeshore, Mtl, Canada, michael.dugdale@johnabbott.qc.ca

James D. Slotta, University of Toronto, 252 Bloor Street W. Toronto, Canada, jslotta@oise.utoronto.ca

Abstract: This paper reports on a new program of research investigating the use of a “smart classroom” technology to scaffold learning in the domain of physics. Using a co-design approach the research team and college teachers developed a computer-supported collaborative collective knowledge physics activity and tool. The activity’s designs aimed to help students overcome problems distinguishing contextual clues in physics, which influence their ability to transfer knowledge. Working first in dyads the students solved, tagged, and provided a rationale for a set of multiple-choice questions. A second stage involved the dyads pairing up as “supergroups” to analyze and critique the aggregated wisdom of the class towards establishing a shared understanding of the concepts being presented. Thirty-two college students participated in the study. Results showed improvements between the dyad and group activities, and highlights how the aggregated visualizations afforded new ways for teachers to gain insight into students’ conceptual misunderstandings in real-time.

Introduction

Over the last decade there has been increasing interest in building technology-rich collaborative learning environments that complement a more social constructivist educational paradigm. Examples include such initiatives as the SCALE-UP project (Student-Centered Active Learning Environment for Undergraduate Programs) at North Carolina State University and TEAL (Technology-Enabled Active Learning) at MIT (Dori & Belcher, 2004). Research outcomes from these programs reveal promising results with regard to student learning, including increased attendance, decreased failure rates, improved user satisfaction, and enhanced conceptual understanding (e.g., Saul, Deardorff, Abbott, Allain, & Beichner, 2008).

More recently, research to improve the interactive, networked, and adaptive potential of such classrooms have resulted in efforts to develop “smart” spaces. Much work is required to understand how to best design the technology for such environments and to bring together the needs of the content domain, theory-based pedagogical practices and technological affordances for learning. This current study is a design experiment (Brown, 1992) that used a co-design approach (Penuel et al., 2007) to build a computer supported collaborative learning environment that leverages the potential of community knowledge and visualization tools, along with an engineered curriculum, to teach physics. We refer to this environment as the Distributed Active Learning Interactive Technology Environment (DALITE). Our main interest in this study was to investigate how the students’ use of the reflection and tagging tools helps to promote discourse, which in turn may help to deepen their understanding of the concepts and broaden the contexts in which these concepts may be applied (i.e., preparing for transfer). At the same time our investigation focused on the scripted orchestration of the learning (Dillenbourg & Fischer, 2007) and how the implementation of DALITE might be improved.

Theoretical Foundations for the Design of DALITE

It is widely agreed that construction of knowledge and active participation is facilitated by inquiry-based activities (Slotta & Linn, 2009) and other forms of problematizing content (Engle & Conant, 2002). Students need to have something to challenge their understanding, to motivate their interest in sense making and to promote their willingness to engage in reflective discourse. Collaboration with peers and intentional reflection is believed to facilitate restructuring of certain beliefs and ideas that generally go uninspected by novices, considered conceptual change (e.g., Sinatra & Pintrich, 2003). We propose that aspects of this restructuring process include identification of the deep structures (i.e., elements of physics principles) and patterns across the different contexts that are presented in physics curricula.

Guided by social constructivist principles such as Vygotsky’s notion of Zone of Proximal Development (ZPD; Vygotsky, 1978) we designed DALITE so that the students participating in the space are aided by having access to the work of their peers. Small group collaboration towards a goal of understanding the subject area provides the social and cognitive support that allows students to achieve results that would not be possible were they to do the work alone (Stahl, 2006). This idea is extended by the notion of a Knowledge Community where students work in close collaboration with their peers and teachers in the formulation of their learning goals, how they will achieve them, and in the exchange and critique of ideas with their peers (Slotta & Najafi, 2010).

Collaborative Collective Knowledge Visualization

A knowledge community is another way of conceptualizing communities of practice (Lave & Wenger, 1991). How it differs is its reliance on new technological capabilities that can bring together distributed knowledge, most importantly, the capability to produce collective knowledge artifacts. For example, *collective collaborative tagging* (Choi, et. al., 2008), a categorization process that can produce emergent ontologies from within a collectively built knowledge repository. At its core, such collective knowledge is dependent on the communication and interactions produced around particular domain thinking, exemplifying learners' growing awareness of norms and practice (e.g., Cobb, 2002). In this way the focus is on community knowledge advancement rather than that of the individual (Scardamalia & Bereiter, 2006).

DALITE provides students with visual representations of such collective artifacts including aggregated group reflections (aka rationales) and collaborative tagging (aka categorization). Such representations might be considered as shared objects or artifacts that facilitate communication between the system's participant communities, allowing for sharing and the development of *common ground* (Clark & Schaefer, 1989).

Design Specifications

The underlying infrastructure that drives the DALITE curriculum centers on a powerful, flexible open source platform called SAIL Smart Space (S3), which in turn is built on the rich framework of Scalable Architecture for Interactive Learning (SAIL; Slotta & Aleahmad, 2009). S3 specifies a framework for the configuration of devices and displays, running off a set of core underlying technologies: (1) a portal for student registration and software application management; (2) an intelligent agent framework for data mining and tracking of student interactions in real time; (3) a central database that houses the designed curriculums and the products of student interactions; and (4) a visualization layer that controls how materials are presented to students on various devices and displays (Slotta, 2010).

Built upon two previously successful studies (Tissenbaum & Slotta, 2009), this project extends the platform to a physics classroom at an urban College in Quebec. The curriculum was developed using a co-design approach, working in close collaboration with physics teachers at the College, to be enacted regularly throughout a semester in one section of the introductory physics course in mechanics.

The curriculum covers the major content areas in mechanics - kinematics, dynamics and energy. Each content area is presented as a separate activity involving a curriculum set of three to four concept questions that may be used as an introduction or a review of the topic area. Influenced by the Ohio State *conceptest* questions (Lee, 2009), each set is sequenced as a series of increasingly difficult multiple-choice problems built on similar deep structures with different surface features, or similar surface features with different deep structures. We propose this design as a possible solution to the problems students have distinguishing contextual clues in physics, which influence their ability to transfer knowledge (e.g., Lobato, 2006). The teacher has control over the selection and upload of the questions using a specially designed teacher portal; thereby he/she can customize the problem set to meet the perceived knowledge level of the students.

The curriculum is orchestrated (Dillenbourg & Fischer, 2007) to include activities at three levels of social organization - the individual, the dyad and the small group (supergroup). At each level the student or students are asked to perform four tasks: (1) categorize the type of question by tagging the major elements (element list provided), (2) write a short rationale to explain the choice, (3) answer a multiple-choice question, and (4) write a short rationale to explain the categorization. The steps are scripted in such a way as to encourage students to think about the underlying principles involved in the problem *prior* to solving it (step 1), and then to reflect on why/how this helped them solve the problem (step 3). These steps are carried out first as homework (at the individual level), and then repeated in class (at the dyad and supergroup levels). At the dyad and supergroup levels students are able to view the collective work of the rest of the class (from the homework phase of the activity) in the form of the aggregated histogram of tags and individual reflections. The aim of this is to provide a richer set of information (using the wisdom of the crowds) to draw from as contextual clues towards solving the problems. At each level students enter their answers into the DALITE system by logging in with their unique user IDs and passwords. As they move from one level to the next the questions become more challenging, requiring the thinking of many minds. Additionally, as students move from individual to dyad, and dyad to supergroup, they are asked to reflect on the collective knowledge produced by their peers.

To illustrate the in-class process, starting in dyads, one of the two students is required to log into the DALITE system. As a pair, the students answer the set of questions one at a time, each time choosing from a list of multiple-choice answers then writing a rationale for the choice. Next, the students are asked to categorize the question by tagging its relevant physics principles (aka elements). Upon submitting these to the system, they move on to the next question and repeat the procedure until the question set is completed.

These answers, reflections, and tags are collected and uploaded to the server and the aggregate of the students' responses are displayed in a representation made available to the teacher to review at any time through a DALITE teacher report (see Figure 1). At the next stage of the orchestration students, working together in *supergroups* (made up of the two dyads), are given the same set of three to four questions but this time asked to

reflect on the answers and rationales generated by their peers. This is presented in a summary visualization, much like the teacher representation (see Figure 1).

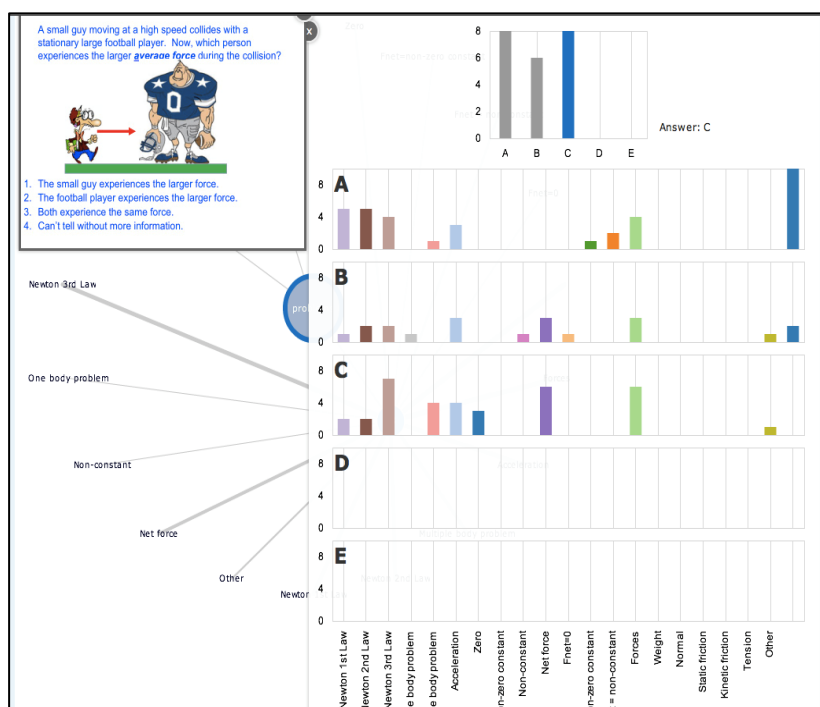


Figure 1. Teacher report showing histogram of students' answers to the multiple-choice question and tagged elements for the respective choice.

The answers are presented in standard histogram style showing the number of students for each of the multiple-choice answers. Clicking on any of the histogram bars reveals the tagged elements list for that particular answer (i.e., categorization of the question selected by students who chose that particular multiple-choice answer). At each stage students are given the time to discuss within their supergroups which answer seems the most correct. They then submit their "final" supergroup answer, categorization (element tags), and rationale for choosing those elements. Each question that was assigned is completed in turn, but the activity is designed so that the teacher can stop the students between questions in order to engage the students in discussion or to correct any lingering misconceptions.

Methods

Research Design and Context

Using a design experiment approach we investigated the learning environment developed for the second implementation of DALITE, introduced as part of an active learning pedagogy that included other active learning approaches, e.g., peer instruction (Mazur, 1997). Participants were a class of 32 first year college science students (17-18 years old) enrolled in an introductory physics course. All classes were held in a technology-rich smart classroom environment, an active learning space with a seating arrangement designed to facilitate collaboration. Configured this way there were eight groups of four, our supergroups made up of two dyads each. The topic covered in this piloted portion of the DALITE curriculum was from the dynamics section (Newton's Laws) of the course in Mechanics. The teacher was a member of the co-design team.

Selection of Physics Problems for Study

For this study we selected a set of four questions about a block on a ramp, sometimes held by friction, sometimes not. The sequencing of the questions was very important, with Question 1 being the easiest and Question 4 the hardest. The four questions share the same deep structural elements, which are variations on Newton's First Law. Thus, while there was a maximum of 16 elements to choose from (Newton's 1st, 2nd and 3rd Law, single body problem, $F_{net}=0$, etc.), only 5 or so elements are relevant to the four questions. In all cases the acceleration of the block is zero ($F_{net}=0$), accordingly, the net force exerted by the ramp must be vertically upwards with a magnitude equivalent to the force of gravity on the block. It was anticipated that the typical introductory-level students would have little problem with Question 1, and would correctly categorize this question. However, for Questions 2, 3 and 4, Newton's 3rd law is essential in deducing the net force on the slide, which would not be as easy to identify and correctly tag.

Data Collected

Recall that the reflection and categorization (tagging) tool was designed to be used on three levels of social context - individual, dyad and small group. We focus here only on the dyad and super-group data. Data collected include the DALITE teacher report, which shows: (1) the raw numbers of students' answers to the four multiple choice questions, (2) the written rationales for the answers, (3) the results of the categorization exercise, with a list of the tagged elements, and (4) the written rationales for the tagged elements. These data are

identified for both the dyads and the super-groups. Audio recordings of a representative sample of four super-groups (eight dyads) were made. Additionally, the teacher orchestration of this implementation was recorded.

Results

The results show the effectiveness of the reflection and categorization (tagging) tool for scaffolding learners' thinking and discourse about the deep structures of the content knowledge.

Answers to Multiple Choice Questions

The impact of the reflections tool (the rationale for answers). From the repository-generated teacher report we see, on average, for Questions 1, 2 and 3, an 80% change towards the correct answers after the dyads discuss their answers in their supergroup (see Figure 2). The difficulty posed by Question 4, however, continued to be challenging with only 50% of the supergroups getting to the right answer. Clear improvements are shown over the course of the activity where 71% of supergroups where both dyads were incorrect changed to the correct answer after the discussion in the supergroup. Additionally, 86% of groups where 1 dyad was wrong showed a change to the right answer after the discussion in supergroups. Additionally, the reflections in writing are much improved in the supergroups.

The impact of the tagging tool (the rationale for tagging questions). Turning to the tagging activity, the data shows that while 80% of the eight supergroups were able to identify and tag the major elements (Newton's 1st Law, $f_{net}=0$, etc.) that number dropped to 40% with the more challenging identification of 3rd Law effects in Questions 2, 3 and 4. However, the three supergroups, Groups 2, 3 and 5 (and later Group 7) who were correct in this identification also produced good justifications for their tagging of Newton's 3rd Law and demonstrated that their discussion as a supergroup had an impact on this change (i.e., the related dyads did not identify this element).

Of the four groups the collected audio data from Group 5 and 7 showed a deepening of their understanding related to the discussion around the DALITE activities. Group 5 got all the questions correct, and largely had reasonable tagging (although they missed the 2-body problem for Question 2). Overall, they seemed to develop a robust understanding of the way Newton's laws are at work in these problems. Group 7 was also interesting in that they seemed to realize that something was missing from their Question 3 thinking and caught their misconception while solving Question 4. On the other hand, Groups 1 and 8 showed very little change as a result of their discussions. From the audio data it appears while one of the four students in Group 8 understood the concepts and could perform the tagging, he choose to go with a majority vote instead of trying to reason out the problem and convince his peers.

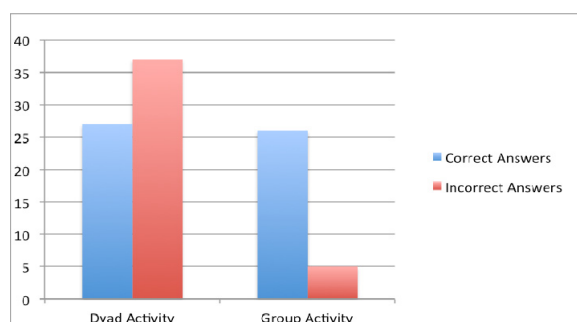


Figure 2. Distribution of correct to incorrect answers for dyads and groups.

Discussion

The finding of improvement in scores across the groups in comparison to the dyads is encouraging. Whether this improvement is a result of students becoming more familiar with the questions and element tags, the ability to see the rationales of their peers, the increased collaborative discourse in the larger groups, or of the “wisdom of the crowd” (i.e., by reviewing the aggregated answers of the class) – or some combination of the above – these results suggest that the curriculum provides value in its ability to guide student problem-solving. This sentiment is highlighted by the groups in which at least one of the dyads answered incorrectly during the first phase of the activity – by leveraging the tools provided to them by this activity many of these students were able to correct their earlier mistakes and in the process construct their own understanding of the curriculum.

The ability for the teacher to see collective product of these interactions through the customized teacher report page was useful in aiding him in understanding the conceptual misunderstandings of the students in the class in real-time. This was particularly useful in that it allowed the teacher to adapt the orchestration of his lesson to address these misconceptions with a greater understanding of the students' needs. Furthermore, by projecting the teacher report onto a large surface in the classroom it was also adapted as a learning tool for the students. The teacher was able to show the collective work of the students and discuss the various answers, rationales, and tags (for both correct and incorrect answers) for each question to further class discussion and reflection.

Taken together the use of the aggregated knowledge, varying contexts of individual and group work, and real-time representations and visualizations opens the door to future research. Moving forward our co-design team plans on investigating other complex pedagogical configurations, including bridging formal and

informal learning contexts, expanding the activity to become part of the regular curriculum of the class, and how availability of a growing and persistent knowledge base can provide new avenues for student inquiry and collaboration.

References

- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141-178.
- Brown, A.L., & Campione, J.C. (1994). Guided discovery in a community of learners. In K.McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press/Bradford Books.
- Choi, J., Rosen, J., Maini, S., Pierce, M. & Fox, G. (2008). Collective Collaborative Tagging System. *Grid Computing Environments Workshop, GCE'08*, pp. 1-7.
- Clark, H. H. & Schaefer, E. F. (1989). Contributing to discourse. *Cognitive Science*, 13, 259-294.
- Cobb, P. (2002). Reasoning with tools and inscriptions. *The Journal of the Learning Sciences*, 11(2&3), 187-215.
- Dillenbourg, P. & Fischer, F. (2007). Basics of computer-supported collaborative learning. *Zeitschrift für Berufs- und Wirtschaftspädagogik*, 21, pp. 111-130.
- Dori, Y. & Belcher, J. (2004). How does technology-enabled active learning affect undergraduate students understanding of electromagnetism concepts? *The Journal of the Learning Sciences*, 14(2).
- Engle, R.A. & Conant, F.R. (2002). Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction*, 20(4), 399-483.
- Hestenes, D. (1992). Modeling games in the Newtonian world. *American Journal of Physics*, 60, 732-748.
- Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Lee, A. (2009). Development and evaluation of clicker methodology for introductory physics courses. (Doctoral dissertation). Available from compADRE. PER/document/ServeFile.cfm?ID=10358&DocID=1838
- Lobato, J. (2006). Alternative Perspectives on the transfer of learning: history, issues, and challenges for future research. *The Journal of the Learning Sciences*, 15(4), 431-449.
- Mazur, E. (1997). *Peer instruction: a user's manual*. Upper Saddle River, N.J.: Prentice Hall.
- Palincsar, A.S. & Brown, A.L. (1984). Reciprocal teaching of comprehension monitoring activities. *Cognition and Instruction*, 1, 117-175.
- Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1).
- Saul, J. M., Dearthoff, D. L., Abbott, D. S., Allain, R. J., & Beichner, R.J. (2000, July). Evaluating introductory physics classes in light of the ABET criteria: An example from the SCALE-UP project. Paper presented at the annual AAEE, Seattle, WA. (ERIC Document Reproduction Service No. ED 459063).
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 97-118). N.Y.: Cambridge University Press.
- Sinatra, G. M., & Pintrich, P. R. (2003). The role of intentions in conceptual change learning. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 1-18). Mahwah, NJ: Erlbaum.
- Slotta, J. D. (2010). Evolving the classrooms of the future: The interplay of pedagogy, technology and community. In Mäkitalo-Siegl, K., Kaplan, F., Zottmann, J. & Fischer, F. (Eds.). *Classroom of the Future: Orchestrating collaborative spaces* (pp. 215-242). Rotterdam: Sense.
- Slotta, J. D., & Najafi, H. (2010). Knowledge communities in the classroom. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education, Volume 8* (pp. 189-196). Oxford: Elsevier.
- Slotta, J. D., & Linn, M. C. (2009). *WISE science: Web-based inquiry in the classroom*. New York: Teachers College Press.
- Slotta, J. D., & Aleahmad, T. (2009). WISE technology lessons: Moving from a local proprietary system to a global open source framework. *Research and Practice in Technology Enhanced Learning*, 4(2), 169-189.
- Tissenbaum, M. & Slotta, J. D. (2009, June). A new framework for smart classroom research: Co-designing curriculum, research and technology. Poster presented at the annual Computer Supported Collaborative Learning (CSCL) conference CSCL 2009, Rhodes, Greece.
- Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Acknowledgment

This study was supported by grants from Dawson College, and the Ministère de l'Éducation et du Loisir et du Sport, Quebec, Canada (PAREA).

Utilizing A Collaborative “Cross Number Puzzle” Game on Group Scribbles to Develop Students’ Computing Ability of Addition and Subtraction

Yen-Hua Chen, Tak-Wai Chan, Graduate Institute of Network Learning Technology, National Central University, Taiwan

Email:oliver@cl.ncu.edu.tw, chan@cl.ncu.edu.tw

Chee-Kit Looi, Yin-Juan Shao, Learning Sciences Lab, National Institute of Education, 1 Nanyang Walk, Singapore 637616

Email: cheekit.looi@nie.edu.sg, yj_shao@hotmail.com

Chiu-Pin Lin, Graduate Institute of eLearning Technology, National Hsinchu University of Education, Taiwan, chiupin.lin@gmail.com

Abstract: While addition and subtraction is a key mathematical skill for young children, a typical activity for them in classrooms involves doing repetitive arithmetic calculation exercises. In this study, we explore a collaborative way for students to learn these skills. In our study, 52 students in Grade 4 (ages 10 or 11) participated in the study and were asked to solve arithmetic problems collaboratively as a group. This “Cross Number Puzzle” was also designed with the “feedback” mechanism to assist students’ problem solving. In the two classes we studied, one class had the students played the game individually and the other class had the students play the game collaboratively. The low-ability students in the collaborative class were found to have made the most significant progress in arithmetic skills through playing this game.

Introduction

Computing addition and subtraction is important mathematical ability in our curriculum. In seeking to design more interesting learning experiences for children to learn math, we designed and implemented a game. The aim of this game is to promote the concept of flexible use of addition and subtraction, and to enhance children’s capacity to build up their arithmetic skills progressively. The purpose of this study is also to explore different collaborative learning patterns that involve students working together on arithmetic problems. We also examine differences between individual learning and collaborative learning collaboratively.

A variety of educators have classified operating addition and subtraction problems into four problem types: change, combine, compare and equalizer (Carpenter, Hiebrt, and Moser, 1981; Fuson, 1992; Gustin and Romberg, 1995). English (1998) pointed out that change and combine are easier while take-away and compare are more difficult challenges for elementary school students. In an arithmetic equation, any of the three numbers could be the unknown number. We adopted this widely method in our study. Fuson (1992) defines these three types of “change” (placeholder) as: Missing End, Missing Change, and Missing Start. Van de Walle (2001) also classified the type of “change” into three types: result-unknown, change-unknown and initial-unknown. The three types of problems present different levels of difficulty to the students. If the student applied the direct modeling strategy by using counters or tally marks to model directly the action or relationships described in the problem, he or she always does not know how many counters to be put down to begin with. Table 1 below illustrates the three levels of change types in problem. Level I is when the result number is unknown. Level II is when the change number is unknown, Level III is when the initial number is unknown (Peterson, Fennema et al. 1991).

Table 1: Three levels of “Change” types in problems.

Change Types	Join(Add to)	Separate(Take from)
Result number unknown	Standard sentence: $A + B = \square$	Standard sentence: $A - B = \square$
Change number unknown	Standard sentence: $A + \square = B$	Standard sentence: $A - \square = B$
Initial number unknown	Standard sentence: $\square + A = B$	Standard sentence: $\square - A = B$

With these three levels in Table 1 in mind, we design our system by having five stages of problem to pose to the students (Table 2):

Table 2: Level of difficulty design.

Level of difficulty	Description	Example
Level 1	Result number unknown – basic skill practice	$A \pm B = \square$
Level 2	Remove operator – between basic skill practice and comprehension application	$A \square B = C$
Level 3	Change number unknown add-to or subtraction – comprehension application	$A \pm \square = B$

Level 4	Initial number unknown add-to and subtraction — comprehension application	$\square \pm A = B$
Level 5	Change number unknown and Initial number unknown, addend or summand type — the most difficult level	$\square \pm \square = A$

Design of the “Feedback” System

A ‘feedback’ mechanism was introduced to the game design in this study. Feedback is considered to have strong impacts on learning process and result (Bangert-Drowns, Kulick, Kulik and Morgan, 1991). Appropriate feedback can lead the learners to focus on key elements of learning. The learner can always adjust their learning strategies to try to close the gap between their actual performance and the goal. They reflect on their learning by a self-monitoring feedback loop. Hence, they can change their learning strategies in the follow-up learning and seek a better way of learning (Alexander and Shin, 2000). Collins (Collins, Carnine, & Gersten, 1987) pointed out three levels of feedback messages: little feedback; just show the answer is right or wrong. basic feedback; descriptive feedback; give some hints to learner, to drive right answer. Descriptive feedback can promote the motivation to challenge new tasks and new problem. Feedback mechanism provided by software systems mainly involves five levels that can get right answer or direction of goals (Sales, 1998) summarized. These five levels are: no feedback, knowledge of response, knowledge of correct response, answer until correct, and elaboration feedback. In our research, the feedback mechanism is designed as follows as figure 1

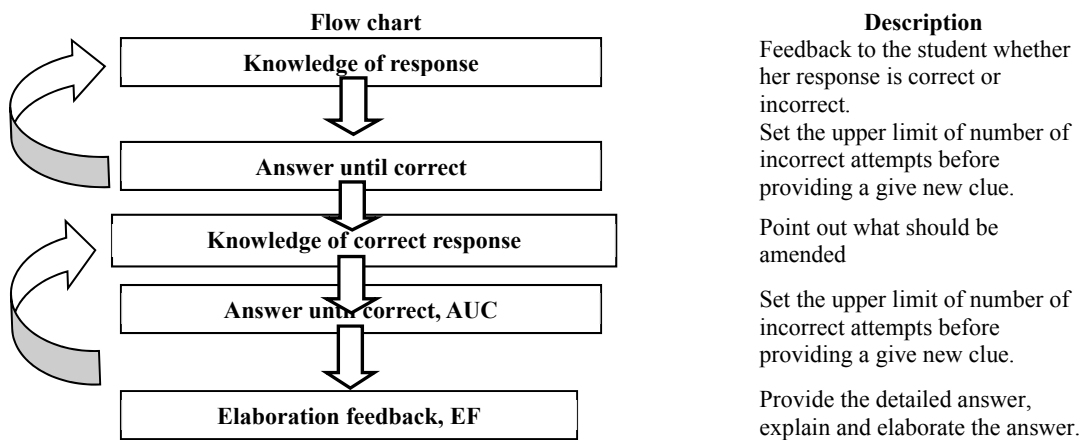


Figure 1. Five-level Feedback Mechanism.

Methodology

Fifty two students in Grade 4 (ages 10 or 11) participated in our study. We had two experimental classes: students in Class A played the ‘Cross number puzzle’ game in small groups, and students in Class B played the game individually. All students were grouped according to their mean scores of the previous three tests in this term.: high-math achievers; medium-math achievers, and low math achievement. Students in class A were divided into homogeneous groups with three per group. We utilized Group Scribble as the platform for the game, and conducted analysis of the collaborative work within these groups. Group Scribbles (GS) is a computer-supported collaborative learning system developed by SRI International to conduct small-group collaborative concept mapping activities. Each student has a mobile device, and sees a screen divided into upper and lower frames. The lower frame is the Private Board that the student scribbles or types her answer individually. The upper frame is the Public Board in which the students show all of their individual answers, and work together as a group. The teacher can monitor their process of learning and provide appropriate guidance.

Questions designed ranging from the easy to the difficult in terms of the five levels of difficulty. When the students complete the calculation, they can fill in the answer box and press OK button below question area to submit. If the answer is correct, there will be a brief description of the key points. If the answer is wrong, the system will execute a step-by-step hints based on the number of errors from the user inputs. The action repeats until the maximum number of errors reaches the upper limit. Then the system will show the correct answer and the methods of problem-solving. The following table shows four different types of questions in the “Cross Number Puzzle”.

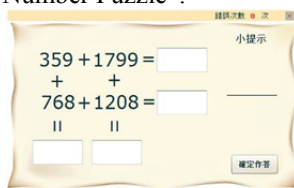


Figure 2. Question Type 1.

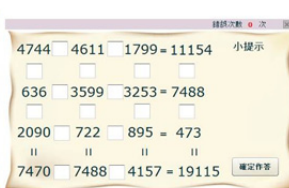


Figure 3. Question Type 2.

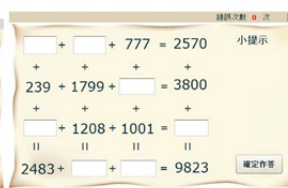


Figure 4. Question Type 3.

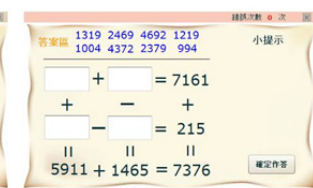


Figure 5. Question Type 4.

Findings

The mean score of Class B is 4.17 higher in the post-test (57.21) than in the pre-test (53.04) a significance level of .026 ($p < 0.05$). This indicates learners made progress through playing the game. Table 3 shows the pre/post-test results of Class A. Students in Class A also have higher average score in the post-test. Their mean score had a great increase by 13.00, from 50.29 in pre-test to 63.29 in post-test ($p = 0.002 < 0.01$). This indicates students in Class A made greater progress than those students in Class B through playing the game collaboratively. Further observation of these collaborative groups implied that the low math-achiever students made the most significant progress, as can be easily gathered from the following table.

Table 3: T-test of pre and post tests in collaborative group.

Number of Participants (N=24)	t-test of collaborative group							
Tests	Participant Number	Min.	Max.	Mean	SD	Progress	t	p
Pre-test of High-achiever	6	63.34	76.68	70.56	3.141	7.22	1.308	.248
Post-test of High-achiever		48.34	100	77.78	10.576			
Pre-test of Medium achiever	9	45.01	66.68	56.48	5.182	6.47	.880	.404
Post-test of medium-achiever		40.01	98.35	62.96	14.454			
Pre-test of low-achiever	9	6.67	55.01	30.56	10.111	23.33	4.834	.001**
Post-test of low-achiever		16.67	76.68	53.89	9.874			

The low-achiever groups in Class A were found the highest increase in post-test scores with high level of significance ($P = 0.001$). This indicates that low-achievers of these collaborative groups derived the most benefits in this study. Table 4 showed further analyses conducted on three different types of test questions on “addition and subtraction”. Students had better scores in all three types of questions in the post-test. But the low-achiever groups achieved significantly highest improvement in questions of “basic computing”, “unknown constant” and “Cross Number Puzzle” with the increase of mean score 9.63, 7.38 and 6.32 respectively. This suggests that these low-achievers benefited the most from the “Cross Number Puzzle” in improving their basic arithmetic skills.

Table 4: Low achieved students' progress in pre and post tests.

Low achievers in Class A (N=9)		Pre - test	Post -test	Average increased scores	Ratio of progress in different questions
Basic computing skills	Score of question 1 to 5 (33.33)	18.52	28.15	9.63	41.3%
Unknown constant	Score of question 6-12 (46.67)	8.90	16.28	7.38	31.7%
Cross number puzzle	Score of question 13 to 15 (20.00)	3.14	9.46	6.32	27.0%

Collaboration

Questionnaire results illustrated 85% students tried to do cooperation and discussion before they submitted the answer when they play the “Cross number puzzle” game. There was one high-achiever student who did not discuss with others when he did his calculations. He explained in the follow-up interview that he was quite confident and only shared his results with others when he completed all his calculations. 87.5% students claimed that it was much easier to complete the calculations with collaboration than to have to do it individually. Those students without confidence in mathematics found it easier to share their own ideas with others and co-complete the calculation. All students agreed that they derive benefits from discussion with other classmates.

“Hints” Usage in Class A and Class B

As we mentioned before, students in Class A play the game collaboratively in groups while students in Class B completed the game totally individually. We can easily conclude from Table 5 below that feedbacks in the form of “Hints” were much more frequently used in Class B than in Class A. It suggests that when students encounter problems and difficulties but without other people’s help, he or she would search help from the “feedback” system. On the other hand, students in Class A would discuss their strategies to solve the problem within a

group first, allocating cooperative work among group members. They only referred to the “feedback” system when all students in the group were uncertain or in a dilemma. They used the “Hints” less often than students in Class B. However either in Class A or Class B, high-achiever students seemed to have used the “Hints” far less than low-achiever students. Low-achieved students relied more on “Hints”.

Table 5: “Hints” usage in Class A and Class B.

Number of use in different group	Class A (N=24)	Class B (N=28)
High-achiever	0.54	0.84
Medium-achiever	0.71	1.31
Low-achiever	1.25	2.09
Average usage	0.86	1.40

Activity 1: Putting the Operator

Four different patterns of collaborative problem solving were found in their activities of “putting the operator”: whole-group-deciding, two-member- deciding, leader-deciding and individual deciding. Group 6 made the decision by all group members. Three groups, Group 1, Group 3 and Group7 decided the answer individually. Two groups took the two-member deciding pattern and the rest two groups took leader-deciding pattern. The following figures (Figure 6 to Figure 9) shows different layout of the game in different collaborative methods. For example, in figure 12, three students in group 6 (one student in one color of “+”) post their answer as 4777 +++ 4611 +++ 1799 = 11154, six “+” and one “=”. All these three students operate the addition correctly. Therefore we could judge that this group’s answer was decided by the whole group. In figure 14, only one answer was pasted, checking the video recording, obviously, this group was leader-deciding.



Figure 6. Whole-group-deciding.

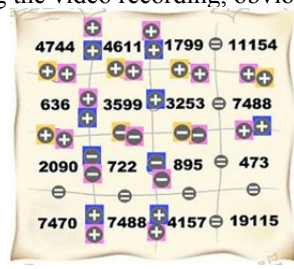


Figure 7. Two-member-deciding.



Figure 8. Leader-deciding.

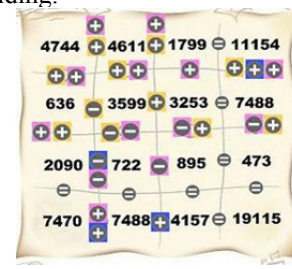


Figure 9. Individual Deciding.

Activity 2: Fill in the Figure in the Formula Sentence

To enable learners get the unknown number in the puzzle by observing, calculating those given numbers and estimating the result, for example , $A \pm \square = B$ & $\square \pm A = B$, tasks division and coordination were necessary in one group. From the procedural layouts of the game on the screen we got some insights of methods of students’ collaboration and their strategies to complete the calculation. The results were shown in Table 6.

Table 6: Methods of collaboration in Class A (8 groups).

Methods	Description	Group	Ratio of different method used
Individual calculation	Group members did the calculation by themselves individually. Little collaboration occurred.	G1 G2	25.0%
Comparison	Started from different thread and compare each other’s result at the intersection	G3 G5	25.0%
Relay	One finish one section and another take over to continue calculating	G4	12.5%
Assisted calculation	One of the group members is in charge of all calculation and other members checking his/her calculating process	G6	12.5%
Through-out calculation	Some members calculate from the beginning to the end and other members calculate from the end to the beginning then they compare at the intersection.	G7 G8	25.0%

Interactive Patterns

Milson (1973) identified seven frequently occurring interactive patterns within small learning groups, namely: *Unresponsive*, *Unsocial*, *Dominant leader*, *Tete-a-tete*, *Fragmented cliquish*, *Stilted*, *Ideal* Three of Milson’s interactive patterns were identified in our study; the ideal interaction occurred most often. The students all did well in their collaboration. The groups doing fragment and unresponsive interaction were not as interactive as the ideal groups. They had fewer communication and little cooperation.

Conclusion and Discussion

Our observations and investigations of the two classes who played the game individually and collaboratively respectively showed some interesting differences. The collaborative learning groups (Class A) were found to have made greater progress than individual learning groups (Class B). It suggests that collaborative learning may have enhanced learning effectiveness. From the statistics, we can conclude the low-achieved students benefited the most in this “cross number game”. Collaboration also plays an important role in enhancing learning in Class A with the incorporation of the “feedback system” and collaboration strategies. In both classes, the low-achieving students accessed the “Hints” most often while the high-achiever the least. The individual learning groups in Class B had much higher frequency of access to “Hints”. The low-achieving students had the highest demand for “Hints” for help. Students in collaborative learning groups presented four different methods of problem solving in their activities of “removing the operator”: whole-group-deciding, two-member-deciding, leader-deciding and individual deciding. In the activities of “fill in the figure in the expression,” the students had five methods of calculations: *individual calculation*, *comparison*, *relay*, *assisted calculation* and *through-out calculation*. Students also showed four different ways of calculation: *free calculation*, *calculate from the top*, *calculate from the bottom* and *calculate from both the top and bottom*.

Future Work

Based on the findings in this study, we make some recommendations for future research. *More time on playing the “Cross Number Puzzle”*: Our study has a limitation on time and scale. To make the cross number puzzle more applicable we may need more experiments and expand the users. *Adaptive feedback*: We only offered phased hints to students in this “Feedback system”. The feedback only includes the general direction of calculation concept and the problem solving process. If we can diagnose and evaluate the individual student’s errors, we can provide each student with the individual corresponding solutions or suggestions to fit his skills.

References

- Alexander, J. M., & Shih, S. S. (2000). Interacting effects of goal setting and self- or other-referenced feedback on children’s development of self-efficacy and cognitive skill within the Taiwanese classroom. *Journal of Educational Psychology*, 92(3), 536-543.
- Applefield, J. M., Huber, R., & Mahnaz, M. (2000). Constructivism in theory and practice: toward a better understanding. *High School Journal*, 84(2), 35–59.
- Bangert-Drowns, R.L., Kulick, C. C., Kulik, J.A., and Morgan, M. T. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research*, 61, 213-238.
- Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice* (pp. 229-272). MIT Press/Bradford Books, Cambridge, MA.
- Carpenter, T. P., Hiebrt, J., & Moser, J. M. (1981). Problem Structure and First-Grade Children’s Initial Solution Processes for Simple Addition and Subtraction Problems. *Journal for Research in Mathematics Education*, Vol. 12, pp. 27-39
- Carnine, D. (1997). Instructional design in mathematics for students with learning disabilities. *Journal of learning disabilities*, 30(2), 134-141.
- Collins, M., Carnine, D., & Gersten, R. (1987). Elaborated corrective feedback and the acquisition of reasoning skills: *A study of computer-assisted instruction*. *Exceptional Children*, 154(3), 254-262
- English, L. D. (1998). Children’s problem posing within formal and informal contexts, *Journal for Research in Mathematics Education*, Vol. 29(1), pp. 83-106.
- Fuson, K. C. (1992). Research on whole number addition and subtraction. Douglas A. Grouws (Eds.). *Handbook of Research Mathematics Teaching and Learning*, pp.243-275. Macmillan Library Reference: National Council of Teachers of Mathematics.
- Gustein, E., & Romberg, T. A. (1995). Teaching Children to Add and Subtract, *Journal of Mathematical Behavior*, Vol. 14, pp.283-324
- Sales, G. C. (1998). Designing feedback for CBI: Matching Feedback to learning and outcomes, *Computers in the Schools*, Vol. 5, pp.225-239.
- Peterson, P. L., Fennema, E., & Carpenter, T. P. (1991). “*Teachers’ knowledge of students’ mathematics problem-solving knowledge*” In J. Brophy (Ed.), *Advances in research on teaching: Vol.2 Teachers’ knowledge of subject matter as it relates to their teaching practice* Greenwich, CN: JAI press, pp.49-86..
- Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice (2nd Ed.)*. Massachusetts: Allyn & Bacon.
- Van de Walle, J. A. (2001). *Elementary and Middle School Mathematics Teaching Developmentally (Fourth Edition)*. Addison Wesley Longman, Inc.

Taking Educational Games to the Afterschool: Teens and Researchers on a Quest in Collaborative Design-Based Research

Jacob Dayan, Yael Kali, University of Haifa, Israel; Technion – Israel Institute of Technology
Email: jacob@dayan.org.il, yael.kali@edtech.haifa.ac.il

Abstract: In our ever-ending quest to promote science education, can we take educational games to the afterschool? Following the *modus-operandi* of the Israeli Scouts, two motivated teens (whom we call Cyberscouts) volunteered to join a collaborative design-based research (which we entitle as ‘co-DBR’). Our shared objective is to design an effective model to bring educational games to the afterschool. This article reports the findings of the first iteration of the Cyberscouts model, in which the Cyberscout leaders designed and implemented the process of bringing the Quest Atlantis educational game to an afterschool setting. We find that the teens’ ability to view the process “like a 10 year old” had a strong impact on the refinement of the model. We conclude that the novel co-DBR approach has the potential to serve as both a productive pedagogical approach, and as an added value to DBR methodology.

Introduction

It is not surprising for parents to find their kids playing video and computer games at their leisure time. With the flock of personal computers, netbooks, smartphones, iPads and game consoles, kids spend more and more time in front of the various media screens. The Pew Research Center (2008) reports that American teenagers (9- 17 year old) spend 9 hours a week, in average, on the Internet. Almost all teens (97%) play video and computer games, about 21% play massively multiplayer online games (Boor & Halpern, 2007; Lenhart, et al., 2008). Yet, many of these games can hardly be considered as educational. (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Lenhart, et al., 2008).

But educational games *do* exist, and few of them use the latest state-of-the-art technologies in order to keep par with commercial games, and create an environment that is both engaging and can enhance in-depth learning in general (Ketelhut, Dede, Clarke, & Nelson, 2006), and science learning in particular (Dickey, 2005; Kafai, 2006). Furthermore, the widespread of broadband internet and computational power have driven the evolution of educational Multi-User Virtual Environments (MUVE) and massively-multiplayer online games. Key benefits of MUVE games are that they can leverage aspects of authentic learning conditions, and they enable design of situations that are not possible or practical in real world (Barab & Dede, 2007; Hoadley & Lee, 2007; Ketelhut, et al., 2006). Rather than embedding “lessons”, the educational MUVE games employ constructivist pedagogy and enable students to engage in science-based activities while promoting socially responsive behavior (Barab & Dede, 2007; Kafai, 2006).

The motivation for this research is driven by a strong personal experience. For the past eight years the first author of this paper has served voluntarily as a Scoutmaster in the Israel Scouts (The Zofim), and have studied (with great admiration) the unique educational enterprise based on youth counselors guiding younger children. The Scouts, as other youth movements, employ a common structure of social activity for children in the afterschool. The Scouts youth movement uses troop meetings, campouts, trips, and community service projects for educational agenda in a fun, playful and socially engaging afterschool setting (Dubas & Snider, 1993; Israeli Scouts Web Site," 2009; Kleinfeld & Shinkwin, 1983). The Zofim pedagogical way of operation is unique, and differs greatly from the US or European Scouts, due to the fact that the guides and mentors of the young scouts are all teenagers (ages 16-18), who carry all the duty for planning, executing and refining their educational work with the younger scouts. We are inspired by the possibility of using a similar model to attract teens to divert “afterschool” time to play virtual educational games.

The Current Research

Our overreaching goal in this research is to promote science learning in informal settings. To do this we decided to develop a model that brings educational MUVE games to afterschool game communities. This model, which we call the Cyberscouts model, suggests engaging teens in mentoring younger kids in playing virtual educational games, with the supporting procedures, tools and structures to ensure the sustainability and the effectiveness of the model. The teens, which we call Cyberscout leaders, receive guidance from a more experienced mentor, which in our study was the first author of this paper.

Since no similar model that we could build on was previously developed, we decided to design the Cyberscouts model using a Design Based Research (DBR) approach (Collins, Joseph, & Bielaczyc, 2004; Kali, 2008), which would enable us to refine our model based on multiple iterations in real-world settings. To build a model that would attract kids so much that they would want to participate in the designed activities in their afterschool time, we knew that we need not just an attractive educational MUVE game, but also activities

designed and led by those who know best what these kids like. We decided to design the process of creating a group of players, training and mentoring them for the duration of the game in a collaborative design process with two teens that we recruited for this Cyberscout leader role.

This approach, in which researchers collaborate with practitioners who have much experience in the field, but less experience in designing technology-enhanced innovation is similar to what Penuel, Roschelle, and Shechtman (2007) defined as 'co-design'. In our study, the cooperation between the researcher as a mentor and the Cyberscout leaders as co-designers potentially goes beyond what Penuel et al. (2007) define as co-design. We decided to expand the collaboration to include not only the design process, but also to involve the Cyberscout leaders (we will refer to them as simply 'leaders') in the iterative design process of DBR. We assumed that both the leaders and us, the researchers, would benefit from making design decisions together based on iterative enactments of the collaboratively designed artifacts and procedures. We entitle this approach as 'co-DBR'.

Our research objectives were three-fold: (a) To design an effective model for afterschool MUVE-game based learning and to explore its effectiveness, (b) To explore the learning processes of the leaders from being involved in such a process, and (c) To examine the potential of the co-DBR approach as both a pedagogical approach, and as an added value to DBR methodology.

This article reports the findings of the first phase of the co-design, in which the first Cyberscout leaders implemented the model with a group of ten kids, and on the conclusions regarding refinements required for the next implementation of the project. Specifically, the research questions we sought to answer were:

- What elements are required in a model that seeks to bring educational contents into afterschool play?
- What are the benefits and challenges for the Cyberscout leaders?

Methods

Context and Design Process

This research is built on top of two existing, well-established educational models. The first is the Quest Atlantis game, with its comprehensive Teacher Toolkit, teacher training material, instructions, game introductory unit, and variety of educational quests and units. This MUVE game, developed at the University of Indiana was chosen because it encompasses social agenda and pluralist values, and combines effective game-based learning with entertainment and fun (Barab & Dede, 2007; Barab, et al., 2005). The second model is the Zofim's operational and pedagogical methods to build and mentor groups of youngsters ("Israeli Scouts Web Site," 2009). While Quest Atlantis is primarily used to run in classrooms or computer-clubs (Barab, et al., 2005), the Zofim methods are focused solely on informal afterschool settings, at the physical, real world, with no cyberspace activity. It is the motivation and experience of the researchers that connects the two worlds together. One researcher with a breadth of experience in mentoring non-cyber Scout Leaders, and the other researcher who is experts in educational technologies and DBR methods.

Consequently, we invited experienced scout leaders to volunteer for this research not only as experienced practitioners, but also as collaborators in design and research of the Cyberscouts model. This is consistent with the Zofim paradigm, in which Scout Leaders assume leadership roles and design their course of action. This positions the leaders that volunteered for this research as experts and equal members of the co-design team.

For the duration of the project (Nov 2009 till April 2010) the leaders and the researcher met for eight co-design meetings, 60-90 minutes each. During this time, the leaders also met three times with the game players, and followed them for a 4-week period. It was the leaders who actually enacted, while being guided by the researcher-mentor. In these meetings they designed the entire process of creating game groups and guiding them through the game process. The leaders designed the approach to take, conveyed key messages for their players, which artifacts to produce, and defined the division of labor in order to get things done on time. They also decided on the initial settings and ground rules. The researcher, as part of the 'co-DBR team' assumed the role of an expert to bring a systematic approach and reflective methods to enrich the decision-making process.

Participants

As mentioned above, the research involved two types of participants: Cyberscout leaders and game players.

1. **Cyberscout leaders.** The leaders were two high-school male students, 17 year old, 11th graders from one high-school, who volunteered to be the leaders and become part of the co-DBR team. The students, Dave and Jack (pseudonyms) have prior experience in guiding younger kids (Jack with the Zofim, and Dave with another youth club). They can be characterized as highly motivated, high-achieving and very occupied students. In addition to studying in demanding school programs, i.e. majoring in chemistry, biology, computer science and ICT, they volunteer to community work, have hobbies, including the Zofim, and like many of their friends, devote much time for computing and gaming.

2. **Game players.** The players were ten younger students, grades 5th to 7th (three girls and seven boys) from a school in a high socio-economic demographic area. The specific school was selected primarily due to the active support of the principal in novel educational projects in general, and in this research in particular. The school opened its door to the leaders, and allowed them to invite kids to join the game. It was up to the kids to decide to sign up to this afterschool activity. They signed up with their parent's consent, and no screening was done.

Data Sources

Our raw data includes transcripts of meetings and interviews with the leaders. This covers about 70% of the eight design meetings (60-90 minute each), two semi-structured interviews (mid-term and end-term), and two reflective meetings at the completion of the project, after which the team generated a Final Recommendations document, which also served as data. More qualitative data was collected from observation notes and a researcher journal. In addition, all artifacts created during the process were collected. This includes electronic data of a Facebook page, website (Google Sites), presentations, invitation cards, YouTube movie, and on-line docs (Google Docs). Finally, the Quest Atlantis log data served as a tool to follow the work of the players.

Findings and Discussion

The co-DBR team, namely the researcher-mentor and the two leaders, made several decisions about the initial conditions and ground rules for this iteration of the design. Some of these decisions (1-3) were made in advance, with full awareness, and some (4-5) were realized as decisions only during the enactment. According to the transcripts of the first two meetings, and the end-term reflective document, this includes:

1. To use Quest Atlantis "as is", with no modifications to its game units, introductory unit, and norms.
2. To use the game in its native language, English, with no localization or translation.
3. To cooperate with the school and build the game group only from its members.
4. To accept all players that want to sign up, without any screening.
5. To use mainly virtual social networking tools, alongside the Quest Atlantis virtual community, as means of communication and bonding.

Design-Related Outcomes

This iteration of the design focused primarily on the model itself and the Cyberscout leaders, therefore data analysis encompassed the leaders only. Following Ronen-Fuhrmann and Kali's (2008) DBR analysis approach, our findings were interpreted as "challenging design outcomes" which needed to be explained and resolved for the next iteration as follows:

1. **Cumbersome sign-up process.** The formal sign-up process required that players would ask their parents to sign multi-page paper consent forms. Out of 23 potential players that expressed an interest to sign up for the game, ten players completed the sign-up process. Additionally, user names were generated only by the administrator. Prior to the enactment, the leaders identified this process as an obstacle: "It's very different from other games, where you just create a user name and password and you are immediately in the game" says Jack (End-term interview). In order to reduce this barrier, the design team made a design decision, which was applied already in the first enactment, to frame this activity in a kind of sign-up ceremony at the end of a group meeting with the leaders. However, evidence shows that this workaround was insufficient, and nearly 60% of the players gave up and didn't complete the sign-up process.
2. **Inadequate introductory unit.** The original introductory unit was designed for classroom use, and requires over 60 minutes to complete. The co-DBR team accepted this as a given, although both Dave & Jack expressed concerns about the length of this unit (Transcripts of meetings 1 and 2). Out of the ten players, only four players passed this stage and continued to play the game. "Kids are the most impatient human beings" says Jack, "an intro unit that takes lots of time to complete, with long reading parts, it is daunting" (end-term interview). Dave and Jack shared the same feeling that the introduction unit is the number one obstacle of the game (end-term interview, final recommendation document).
3. **Communication difficulties.** The artifacts and electronic data show that the leaders used all popular means of communication. A website for announcements, a Facebook group, IM and Skype, emails, and sms's. However, the leaders reported about difficulties in communicating with the players. Most players ignored emails and messages and log in when they chose to, and not when leaders were available for online support purpose. Being in a free-choice, informal settings, the players ignored requests to sign in at specific times.

Cyberscout Leaders' Related Outcomes

We find that the two leaders assumed a double role, as educational leaders as well as design "researchers", and intentionally navigated between these roles to rationalize their decisions in the following manners:

1. **Identifying educational potential.** As educational leaders, they made critical remarks about the game and how it can be most effective in afterschool settings. For instance, in the final reflective meeting, Dave and

Jack highlight that most units in Quest Atlantis deal with real-world dilemmas. “I like the method of open debates” says Jack, “... we need to do it at physical meetings... you achieve a lot in these debates, it opens up the opportunity to meaningful learning and kids learn a lot”. Jack suggests doing it at the same way it is done at the Zofim. “There are moral dilemmas and social conflicts [in the Plague unit] ... and in an open debate you can reach deep level of discussions and kids learn from it. They don’t need to change their minds, but they learn to listen to other views and this is equally important”, says Jack.

2. **Assuming a researcher’s role.** One of the initial constraints was the decision to stick to the English language of the game, with no localization or translation. The leaders brought up this issue several times to the discussion, but refrained from taking a stand about this topic until they studied it carefully and collected “empirical evidence”.
3. **Assuming a designer’s role.** Dave and Jack reflect on the relationship between the school and the afterschool, and the linkage to the Zofim in the Cyberscouts model. “The school is just a convenient way of communication [with the players]” says Dave, “it is just a resource”. “We don’t want to be perceived as school-related afterschool activity” agrees Jack, during the final reflective session. They both reiterate this several times, and explain that linkage to school will deter kids from joining. Similarly, they suggest to refrain from linkage to the Zofim youth movement. “I’m sorry”, says Dave, in a polite attempt not to hurt the researcher feelings, “it will have negative connotation for kids [who are not enrolled to the Zofim]”.

Co-DBR Related Findings

The two leaders formed, together with the researcher, a design-based research team. Our findings show that although the researcher served as a “grown-up supervisor”, the leaders saw themselves as equal partners in the co-DBR team. This was evident in the transcript of the final team meetings and the content of the final recommendation document, in instances in which the leaders did not hesitate to challenge the researcher or the Quest Atlantis design team. For instance, Jack said “we have an advantage. We have a closer point of view (to the kids). This is not like a 30-year old teacher trying to think like a 10-year old kid. We think closer to his age, so I can tell what is more fun, what is less fun, a closer point of view”. Consequently, both Dave and Jack vote against the researcher suggestion to link the afterschool game activity to the school, even indirectly. They voice their opinion with confidence, and are not derailed by the researcher’s (potential) authority.

Lessons Learned about the Model and about co-DBR

We find ourselves, at the end of the first iteration with conclusions in two arenas: (a) a local arena related to improving the Cyberscouts model so that it will better serve the goal of bringing science into the afterschool, (b) a more general arena summarizing the lessons learned regarding the co-DBR approach.

How to Improve the Cyberscouts Model

In addition to conclusions regarding the obvious need to remove obstacles, such as the sign-up process and the introductory unit, which were addressed by the Quest Atlantis design team, independently from the current research, the following conclusions were made regarding the Cyberscouts model:

1. **Social proximity.** To increase communication, it is important to maintain a certain social proximity between the Cyberscout leaders and the group of players. Players and leaders should either live in the same neighborhood, or study in the same school. We found out that even when we bring skilled leaders, it is difficult to overcome communication barriers and the lack of some sort of acquaintance. By electing to cooperate with a school in different township, our communication was not effective, and our leaders lost the ability to communicate with the kids during school breaks or immediately after school hours.
2. **F2f vs. virtual social networking.** The virtual social networking tools were not sufficient to create the social capital needed for the game players. In the informal setting of the afterschool, the virtual tools were not enough to grab the players’ attention and call them for action. F2f social networking is required not only for practical reasons, such as training sessions, but also for improving communication by speaking at school breaks. We conclude that the f2f social networking is also required to create a team of players, with the benefits of playing together in the game rather than playing as a set of individual players.
3. **Reflective player group meetings.** As one of the Cyberscout leaders suggested, periodic face-to-face meetings of the whole player group have the potential to enhance the learning experience. The meetings can enhance the social bonding of the group, and improve the cooperation between the players while questing on Quest Atlantis.
4. **School - afterschool relationship.** Following the strong evidence reflected in our findings, we will modify the model to use the school as a resource only, and remove the linkage to school as a part of the model.

Benefits of the co-DBR Approach

This study defines a novel extension to the already mature DBR methodological approach, by integrating it with the relatively new co-design approach. Co-DBR takes advantage of both DBR and co-design. It maintains the

systematic and iterative manner in which DBR investigates learning in the context of design. But it also enables to incorporate into the design a fresh perspective brought by a practitioner (who is a teacher in Penuel et al (2007) but a teenager in the current study). Our findings show that co-DBR is a win-win situation with clear benefits for both the practitioner and the researcher. The leaders' benefit in the current research was evident from their great satisfaction of the collaboration. They felt that they learned a lot, and maintained their enthusiasm even though the implementation did not work as expected. The benefit for us, the researchers was invaluable – we are now equipped not only with innovative ideas for how to refine the Cyberscouts model, but also with a viewpoint of “insiders”, who know best how to attract kids to participate in this model.

We view co-DBR as both a pedagogical and a methodological approach. It is pedagogical, because it can be used to help practitioners learn important things about the learning/teaching environment they are part of. It is methodological in a similar way that DBR is methodological, but extends the viewpoint of the researcher with the perspective provided by the partnership. Finally, co-DBR seems to have a great potential, especially for exploring design for informal learning contexts, in which our perspective of learning, as researchers, is still limited. More research is required to get a better understanding of how the collaboration in co-DBR can work best, and to define guidelines for pursuing this promising direction in a productive manner by other researchers.

References

- Barab, S., & Dede, C. (2007). Games and Immersive Participatory Simulations for Science Education: An Emerging Type of Curricula. *Journal of Science Education and Technology*, 16(1), 1-3.
- Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*, 53(1), 86-107.
- Boor, T. d., & Halpern, L. K. (2007). *Creating & Connecting: Research and Guidelines on Online Social — and Educational — Networking*. Alexandria, VA: National School Boards Association.
- Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *Journal of the Learning Sciences*, 13(1), 15-42.
- Dickey, M. (2005). Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development*, 53(2), 67-83.
- Dubas, J., & Snider, B. (1993). The role of community-based youth groups in enhancing learning and achievement through nonformal education. *Early adolescence: Perspectives on research, policy, and intervention*, 159-174.
- Hoadley, C., & Lee, J. J. (2007). Leveraging Identity to Make Learning Fun: Possible Selves and Experiential Learning in Massively Multiplayer Online Games (MMOGs). *Innovate*, 3(6), 9.
- Israeli Scouts Web Site. (2009). *Israeli Scouts* Retrieved 1-Oct-10, 2009, from http://zofim.org.il/about_tnua_english.asp
- Kafai, Y. (2006). Playing and making games for learning: Instructionist and constructionist perspectives for game studies. *Games and Culture*, 1(1), 36.
- Kali, Y. (2008). The Design Principles Database as means for promoting design-based research. In A. E. Kelly, R. A. Lesh & J. Y. Baek (Eds.), *Handbook of design research methods in education: Innovations in science, technology, engineering, and mathematics learning and teaching* (pp. 423-438). Mahwah, NJ: Lawrence Erlbaum Associates.
- Ketelhut, D. J., Dede, C., Clarke, J., & Nelson, B. (2006). A multi-user virtual environment for building higher order inquiry skills in science. *American Educational Research Association*.
- Kleinfeld, J., & Shinkwin, A. (1983). Lessons Out-of-School: Boy Scouts, Girl Scouts and 4-H Clubs as Educational Environments. *eric.ed.gov*.
- Lenhart, A., Kahne, J., Middaugh, E., Macgill, A. R., Evans, C., & Vitak, J. (2008). *Teens, Video Games, and Civics*. Washington, D.C.: Pew Research Center, Pew Internet & American Life Project.
- Penuel, W., Roschelle, J., & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1), 51-74.
- Ronen-Fuhrmann, T., & Kali, Y. (2008). How to design educational technologies? The development of an instructional-model. In V. Jonker & A. Lazonder (Eds.), *Proceedings of the 8th International Conference of the Learning Sciences: Creating a learning world*. International Society of the Learning Sciences Utrecht, Netherlands.

Acknowledgments

We would like to thank Tamar Ronen-Fuhrmann and Sasha Barab for helping us in developing the concept of Cyberscouts and the Cyberscouts model. We are also thankful to the Quest Atlantis team for enabling us to use the game and their openness to make changes that are relevant for our project.

Enhancement Effects of Online Edutainment Game-Play on Students' Scholastic Achievements in English and Mathematics

Diane Hui, The University of Hong Kong, Pokfulam Road, Hong Kong, diane.hui@gmail.com
 Anthony R. Dickinson, Academic Research Laboratory, Global Choice Psychometrics, Hong Kong,
 anthony.dickinson@gmail.com

Abstract: Whether online edutainment gaming can enhance active student learning, and/or have effects on general intelligences and scholastic achievements remains debatable within education. This study provides empirical evidence of learning as mediated through a novel purpose-built edutainment game-play programme called *e@Leader* on students' general intelligences and scholastic achievements in English and Mathematics, with 80 primary school students in a 2 x multivariate experimental-control study over four months. Student performances were measured in pre-post IQ and comprehension tests, and school's scholastic results, with additional data gathered from pre-post questionnaires, classroom observations and interviews. Pre-post intervention results showed significant increases of scholastic performances between groups in both English and Mathematics, and within the experimental *e@Leader* group regarding differential high-low participation levels ($p < 0.05$). Follow-up analyses provided useful information regarding curriculum integration issues, thus supporting the claim for enhancement effects of online edutainment games upon student scholastic achievements, in an Asian educational context.

Introduction and Theoretical Perspectives

Whether online edutainment gaming can really enhance active student learning, or have effects on general intelligences (IQ) and school academic performance remains debatable issues within education, and is also of great interest to educational researchers, policymakers, educators and parents.

Research results concerned with effects of computer-mediated game-play in student learning and development varied in the literature. On the one hand, critics of computer-mediated video games claim that students' use of computer-mediated video gaming is having a negative effect upon either their scholastic achievements or academic development, cognitive and social intelligences (e.g., Walsh, 2004; see also Craik & Lockhart, 1972; NIMF, 2002; for a more recent review, see Byron, 2009). However, little empirical data has yet been put forward by these critics to confirm their concerns for computer-mediated gaming as a productive learning tool and activity.

On the other hand, the impact of the use of video games for accomplishing educational learning is shown to be rather promising in the literature (e.g., Dickinson & Hui, 2010; Gee, 2003; Prensky, 2006). For instance, research has shown the following key findings: (a) Tests of general fluid intelligence (Gf) may be found to correlate with scholastic aptitude, for example, with regard to performance in school-based language and mathematics tests (e.g., Pind, Gunnarsdottir, & Johannesson, 2003), and computer-based cognitive learning tasks (e.g., Jaeggi, Buschkuhl, Jonides, & Perrig, 2008). (b) Frequent classroom use of the Internet, together with facilitative web-based learning environments can foster potential learning opportunities for students in terms of promoting higher levels of engagement, enhanced personal knowledge gain, and more diverse knowledge acquisition (e.g., Coiro, 2003). (c) Carefully planned video game usage has positive effects on the curriculum, in the engagement of students' deeper learning (e.g., Coller & Scott, 2009), facilitation of students' growth in "smart thinking" (Restak, 2009, p. 149), development of intelligence and social autonomy (e.g., Laird, 2007), significantly increased student attention and awareness to visual events (e.g., Green & Bavelier, 2003, 2006), and faster response times as measured by general perceptuo-motor enhancements and specific eye-hand coordination development (e.g., Dye, Green, & Bavelier, 2009). (d) The design of edutainment games can help reorganize brain processing areas such as perceptuo-motor and eye-hand coordination to enhance more efficient learning behaviors (e.g., Achtman, Green, & Bavelier, 2008; Gopher, Weil, & Bareket, 1994). General intelligence is often measured in terms of IQ scores. As IQ scores reliably correlate with speed of processing, the question as to whether gaming might lead to an increase in IQ has also been raised (e.g., Restak, 2009).

Despite the promising research outcomes, researchers such as Coiro and Restak do not seem to provide a clearly defined programme and explicit architecture for optimal design and effective learning outcomes. Besides the lack of controlled groups in many studies (e.g., Dickinson, 2008), there is also a lack of any online edutainment system which is capable of both the delivery of scaffolded tasks of increasing levels of difficulty (according to student performance success based on auto-regulative learning), and automated assessment of performance with such tasks being built into its operating system. This study aims to rectify these issues.

In summary, the claims for the enhancement effects of online edutainment gaming in formative school educational practice in terms of any improvements in scholastic achievements remains to be empirically tested.

Extending a previous study conducted in a primary school in Singapore (e.g., Dickinson & Hui, 2010; Tan & Boon, 2007), this study further examines the effects of a purpose-built online educational gaming and assessment programme called, *e@Leader*, on general intelligences and students' scholastic achievement, and the extent to which *e@Leader* might be incorporated effectively into the extant school curriculum to enhance improved students' scholastic performance in English and Mathematics, with primary school students in an Asian educational setting, such as Hong Kong.

The findings of this study will increase knowledge and practical understanding of the specific ways in which innovative edutainment gaming, such as *e@Leader* can enhance active student engagement and learning (Dickinson & Hui, 2010), and thus will inform future larger scale explorations in different cultural settings. The learning process will also enrich students' learning experience through the use of a technologically-mediated tool in both a fun and experiential way (e.g., Vygotsky, 1986; Wertsch, 1985, 1991).

What is *e@Leader*?

e@Leader is a purpose-built and self-paced online edutainment system incorporating real-time auto-regulatory psychometric assessment which aims to enhance students' general intelligence and the learning of socio-emotional 'soft' skills (e.g., metacognitive, academic, sensory-motor and social personal skills) through 260+ different *e@Leader* games, including more than 1,000 comprehension quizzes called Brainboxes, with each focusing on a range of comprehension knowledge and skills such as literal, analytic, interpretive and critical levels of understanding.

The construction of *e@Leader* was informed by research-based knowledge in neuroscience (e.g., Calton, Dickinson, & Snyder, 2002; McGonigle, Chalmers, & Dickinson, 2003; Minsky, 1985), cognitive psychology and artificial intelligence (e.g., McGonigle, 1991) and education (e.g., Bransford, Brown, & Cocking, 1999), with reference to principles in experiential learning and student-centered inquiry (for detail, see Dickinson & Hui, 2010). Currently available to 400 primary schools in Hong Kong, the careful design and contribution of *e@Leader* has been recognized by the communities in Hong Kong, winning the Creativity Award in 2008 and ICT Award in 2009.

Research Questions

This study addressed some questions: (1) Does online edutainment gaming enhance active student learning (e.g., Gee, 2003; Prensky, 2006)? (2) Does online edutainment game-play participation have effects on: (a) students' general intelligence (IQ), and/or (b) scholastic achievement (e.g., Pind et al., 2003; Jaeggi et al., 2008)? (3) What are the possibilities and challenges for integrating *e@Leader* into the school curriculum in Hong Kong?

Methods, Techniques, or Modes of Inquiry

Participants

A cohort of 80 4th graders ($N = 80$) with mixed academic abilities was recruited from two classes in a primary school in Hong Kong. Students in one class were assigned the experimental group ($n = 40$) and the other as the matched control group ($n = 40$), as recommended by the teachers. The teachers also mentioned that the students in the control group demonstrated better scholastic performance than the students in the experimental group.

Design and Measures

This study was both experimental and analytical, utilizing mixed quantitative and qualitative methods following institutional human subject research guidelines.

Quantitative inquiry was derived from a 2 x multivariate design. Students' multiple performance data on intelligences and scholastic achievements were obtained through independent pre-post-course psychometric assessment measures of general (Raven's Standard Progressive Matrices test or SPM) and emotional intelligences (BarOn) (e.g., Dickens & Flynn, 2001), together with standardized school tests of English and Mathematics as routinely practised by the school. An additional independent measure of a paper-and-pencil English comprehension test was also conducted to examine students' information processing and reasoning abilities. Pre-post questionnaire responses were also gathered concerned with the students' background information and game use experiences.

Qualitative data were collected through classroom observation related to *e@Leader* implementation and student-teacher interactions, semi-structure interviews with selected students representing a range of participation levels and teachers from different subjects focusing on in-depth *e@Leader* use reflection and curriculum integration issues, and researchers' field notes through participant observation. Classroom observations and interviews were video-recorded and transcribed for analyses.

Procedure

Pre-course scholastic examination grades, questionnaires, psychometric and comprehension tests were collected from all participants prior to the study in March, 2010.

Then, each experimental group student engaged in a daily interaction with *e@Leader* for a maximum period of 30 minutes per session, 7 days per week through a personal online *e@Leader* account between March to June, 2010. A formative activity report was presented to the teachers in May, 2010.

After a four-month daily *e@Leader* interaction, post-course scholastic examination grades, modified questionnaires, and psychometric and comprehension tests were collected from all participants in June, 2010. Two classroom observations were video-recorded. Semi-structured interviews were conducted with 4 teachers and 15 experimental students from the *e@Leader* group and were later transcribed for analyses.

Analyses

Quantitative data were analyzed statistically with a analytic software called Stat3. Qualitative data such as interviews and discourse in classroom observations were coded and analyzed based on themes from a discourse analysis perspective (e.g., Cazden, 2001; Gee, 1999) using a software data management tool called Atlas.ti.

Results and Discussion

Analyses of this study showed some important findings.

Firstly, the findings of this study echo the key idea as proposed by Gee (2003) and Prensky (2006) that active student learning and performance could be enhanced by the use of online edutainment gaming systems, as indicated by empirical evidence concerning increases in scholastic English and Mathematics test scores in primary school students, with experimental (*e@Leader*) and non-exposed control (*non e@Leader*) groups using *e@Leader*, and students' active learning as observed in their daily online participation in terms of exposure and usage. For example, one-tenth of the students participated more than 85% time during the 4-month interaction period, with 4 students participated almost on a daily basis during the entire intervention period. Furthermore, students' active participation and enthusiasm as demonstrated individually and in groups was observed during classroom observation and interviews with students. For example, a student commented in an interview that "At first I don't think it is fun, but [I] got better and better." Another student expressed that "Thank you for letting us play *e@Leader* and we get to exercise our brains. I think I learn many things through *e@Leader*. Also, I am very happy. Although I made some mistakes while playing the games, but now I know."

Secondly, with regard to the specific effects of online gaming interaction based on IQ, there is no significant difference between the experimental (*e@Leader*) and control (*non-e@Leader*) group users. This finding contrasts the findings of previous studies (e.g., Jaeggi et al., 2008; Pind et al., 2003) including the one conducted by the authors in Singapore (e.g., Dickinson & Hui, 2010). Such contrasting finding might be explained by the short intervention time (i.e., 4 months). A comment made by a teacher in an interview echos this concern, "time is too short ... you may see effects in half a year to 9 months with students in P. 4."

Moreover, the comparative performance of students scholastic examinations in English and Mathematics revealed mean score differences in some scholastic areas *between* the experimental *e@Leader* and *non-e@Leader* control groups.

Table 1: Baseline vs. 4-month *e@Leader* exposure comparisons for English and Mathematics: Experimental ($n = 40$) vs. controlled groups ($n = 40$).

Student Group/Exam Score	English Grammar		Mathematics	
	Baseline	4 Months	Baseline	4 Months
Experimental Mean Score	86.30	84.40	81.70	86.63
Control Mean Score	91.60	88.20	88.70	89.77
	$*p < 0.005$	$p > 0.05$	$*p < 0.0005$	$p > 0.05$

Table 1 shows that baseline comparisons of experimental (*e@Leader* users) versus control students, of the same grade and class standard in terms of both English and Mathematics showed significant differences in their grade scores, despite the latter examination being of a greater level of difficulty.

Specific analyses within the *e@Leader* group in relation to their differential participation levels showed additional important findings.

Table 2: Baseline vs. 4-month *e@Leader* exposure comparisons for English and Mathematics: Experimental group only ($n = 40$).

Student Group/Exam Score	English Grammar		Mathematics	
	Baseline	4 Months	Baseline	4 Months
Experimental Mean Score (high frequency users)	87.60	84.70	83.50	86.80 ($*p < 0.05$)

Control Mean Score (low frequency users)	85.20	81.20	79.60	
	$p > 0.05$	$*p < 0.05$	$p > 0.05$	

Table 2 shows that, baseline comparisons of *within*-sample partitioning of the *e@Leader* user group according to their relative exposure and usage, (i.e., the highest vs. lowest third in terms of login frequency) revealed no significant differences in their baseline grade scores for both English and Math examinations.

However, post intervention results (i.e., after 4 months *e@Leader* interaction exposure) revealed significantly differential effects in English, with those students using the *e@Leader* programme the most showing an average 3-4 % point higher performance relative to the lower frequency users. This finding of the scholastic improvement with *e@Leader* users in English is consistent with our additional independent pre-post comprehension tests. For example, the *e@Leader* users made improvement in each of the 5 comprehension sub-tests, whereas non-*e@Leader* users made improvement only in 3 of the 5 comprehension sub-tests; and their cumulative improved scores were higher than those made by the non-*e@Leader* users (i.e., +65 vs. +6 correct points respectively). In terms of Mathematics, for the high (but not the lower frequency) users of *e@Leader*, the average difference between the baseline and final Math examination scores was significantly increased.

Follow-up analyses showed some consistent findings.

In terms of the students' perception of their scholastic improvements in English, Mathematics and confidence in learning as a result of online edutainment gaming participation, a majority of the *e@Leader* users perceived that online edutainment game-play can improve their English, Mathematics and confidence in post-intervention responses, whereas only approximately half of the non-*e@Leader* users perceived such improvements (e.g., 68% vs. 42 % for their perceived improvement in English, 64% vs. 42% for their perceived improvement in Mathematics, and 58% vs. 47% for their perceived improvement in confidence, for the *e@Leader* and non-*e@Leader* users respectively.) As regards the specific responses to the *e@Leader* programme, the post-intervention responses of the *e@Leader* users were similarly different (i.e., 75% for their perceived improvement in English, 49% for their perceived improvement in Mathematics, and 61% for their perceived improvement in confidence).

It is interesting to note that the students' perception in school grade improvements contrasted the teachers' perception of students' improvements for English and Mathematics as a result of online edutainment game-play. For example, 4 of 5 teachers interviewed did not think that there would be any improvements in students' scholastic grades in English and Mathematics. While the *e@Leader* users did demonstrate scholastic improvements in the post-intervention measure, it would seem interesting that the students' perception of their scholastic achievements as a result of online edutainment gaming reflects more consistently their game-play behaviour outcomes than their teachers' perception.

Both *e@Leader* and non-*e@Leader* users revealed similar reflections in their enjoyment in recent game-play participation. For example, *e@Leader* users showed a slightly higher level of enjoyment in both pre-post intervention responses (e.g., 95% vs. 88 % and 81% vs. 74 % with regard to enjoyment, for the *e@Leader* and non-*e@Leader* users in their pre- and post-intervention responses respectively).

To sum up briefly, the students in the *e@Leader* group made more explicit improvement than those in the control group, as a result of the *e@Leader* exposure and interaction.

Concluding Remarks

Extending the previous study (Dickinson & Hui, 2010), it is rewarding to observe in this study students' active learning can be operationalized through edutainment-game-mediated tool in a fun and experiential way across the different data sets. This study has provided empirical findings to demonstrate scholastic improvements in English and Mathematics both between and within groups. Also, the design of *e@Leader*, has accomplished the technical scaffolds lacking in many edutainment systems.

The following claims can now be put forward based on our findings from multiple data sources.

In response to the first research question, the findings support claims for the use of at least one purpose-built online educational gaming system (i.e., *e@Leader*) in enhancing active student learning, as measured by school students' scholastic performance differences in English and Mathematics and with reference to their participation levels, that is, higher vs. lower frequency levels (Gee, 2003).

In response to the second question, contrary to previous studies (e.g., Dickinson & Hui, 2010; Jaeggi et al., 2008; Pind et al., 2003), after four-month's daily interaction with *e@leader*, results showed no differences in IQ score categorization, excepting *e@leader* exposure (i.e., high vs. low frequency users). In addition, there are differences between the experimental (*e@Leader*) versus control (non-*e@Leader*) users in scholastic achievements in English and Mathematics, both between and within groups.

Last but not least, follow-up analyses of multiple data sets illustrate the complexity of the issues. The findings have useful implications for integrating online edutainment gaming into the school curriculum. Based on the teachers' responses from the interviews, some useful strategies and challenges are outlined below:

To fruitfully integrate online edutainment gaming experience within the school curriculum, the process should incorporate the following important aspects: (1) It should be supported through a “whole-school” approach involving collaborative research-teacher partnerships in careful and long-term planning, and implementation. (2) The content of the edutainment system should align with the content provided within the curriculum. (3) The design of online edutainment system should be thoughtful, for example, adopting a “sensory” approach to using both “games” and “songs” and supported via an interactive platform which will allow teachers to freely navigate and utilize the system for learning and teaching instruction and activities, both within and outside classrooms, and through online and face-to-face interaction.

However, the integration process can be time-consuming and challenging in terms of work load issues, lack of instruction time in terms of priority and funding issues, and mentoring and training issues to share experiences within a collaborative learning community. The current group of teachers was all very enthusiastic with the use of online edutainment gaming in motivating students to learn, but they were not entirely convinced that such practice will lead to any scholastic improvements in English and Mathematics.

In summary, it is our current belief that the environmental effects of providing specific training and curriculum content through online, computer-based edutainment gaming systems can indeed lead to increases in students’ scholastic performance by the transfer of core cognitive skills learnt whilst engaging with such educational tools (e.g., Tan & Boon, 2007; Yung & Dickinson, 2008).

For future research, the authors may explore issues involving multi-users in student-centered learning with larger groups of students at multiple grade levels, both within and across sociocultural groups, over a longer period of time, and new topics such as the washback effects of online educational games in teaching and learning, policy-making issues involving learner autonomy and self-regulation in life-long learning.

Key References

- Achtman, R., Green, C. S., & Bavelier, D. (2008). Video games, visual system damage, and plasticity. *Restorative Neurology and Neuroscience*, 26, 435-446.
- Calton, J. L., Dickinson, A. R., & Snyder, L. H. (2002). Non-spatial motor-specific activation in posterior parietal cortex. *Nature Neuroscience*, 5(6), 580-588.
- Coiro, J. (2003). Reading comprehension on the Internet: Expanding our understanding of reading comprehension to encompass new literacies. *The Reading Teacher*, 56, 458-464.
- Dickinson, A. R., & Hui, D. (2010). Enhancing intelligence, English and Math competencies for the classroom via *e@Leader* integrated online edutainment gaming and assessment. In D. Russell (Ed.), *Cases on collaboration in virtual learning environments: Processes and interactions* (pp. 263-283). Hershey, PA: IGI Global.
- Dye, M. W. G., Green, C. S., & Bavelier, D. (2009). Increasing speed of processing with action video games. *Current Directions in Psychological Science*, 18(6), 321-326.
- Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (revised ed.). New York, NY: Palgrave MacMillan.
- Green, C. S., & Bavelier, D. (2006). Effect of action video games on the spatial distribution of visuospatial attention. *J. of Experimental Psychology: Human Perception and Performance*, 32(6), 1465-1478.
- Jaeggi, S. M., Buschkuhl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences*. Retrieved July 20, 2009, from <http://www.pnas.org/content/early/2008/04/25/0801268105.full.pdf+html>
- Laird, J. E. (2007). *Using computer games to develop advanced AI*. Unpublished manuscript retrieved May 21, 2009, from <http://ai.eecs.umich.edu/people/laird/papers/Computer01.pdf>
- McGonigle, B. O., Chalmers, M., & Dickinson, A. R. (2003). Concurrent disjoint and reciprocal classification by *Cebus apella* in seriation tasks: Evidence for hierarchical organization. *Animal Cognition*, 6, 186-197.
- Minsky, M. (1988). *Society of mind* (Touchstone ed.). New York, NY: Simon & Schuster Inc.
- Pind, J., Gunnarsdottir, E. K., & Johannesson, H. S. (2003). Raven’s standard progressive matrices: New school age norms and a study of the test’s validity. *Personality and Individual Differences*, 34, 375-386.
- Prensky, M. (2006). *Don’t bother me mom – I’m learning!* St Paul, MN: Paragon House Publishers.
- Restak, R. (2009). *Think smart: A neuroscientist’s prescription for improving your brain’s performance*. New York, NY: Riverhead Books.
- Tan R., & Boon, C. N. (2007). *e@Leader: Engaging pupils in active learning through a self-paced online edutainment programme*. *Celebrating Learning Through Active Research*, the Ministry of Education, Singapore.
- Vygotsky, L. (1986). *Thought and language* (A. Kozulin, Ed. & Trans.). Cambridge, MA: The MIT Press. (Original work published in 1934).
- Walsh, D. (2004). *Why do they act that way? A survival guide to the adolescent brain for you and your teen*. New York, NY: Free Press.
- Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: HUP.

How a New Actor Was Temporarily Enrolled Into the Network of Game Playing

Mark Chen, University of Washington, Box 354941, Seattle, WA 98195, markchen@uw.edu

Abstract: This short paper uses actor-network theory to describe how an add-on (a user-created modification) was temporarily used to diagnose problems a group of game players was having with a particular in-game activity. The players were engaged in a high-stakes collaborative activity called *raiding* in the massively multiplayer online game (MMOG) *World of Warcraft* (WoW). They met twice a week for a 10-month period to defeat common game-controlled monsters. The add-on's use complicates the notion that tools are necessarily used in a way they were designed to be used. Instead, "in the wild" practice emerges out of the push-pull relationship of competing parties and objects.

Introduction

This paper uses an actor-network theory (ANT) (Latour, 1987, 2005) lens to document how a new technology was enrolled into the work of an existing player group within *World of Warcraft* (WoW), necessitating a change in how roles and responsibilities were distributed among all the actors in the network. This work is important to education because it helps us understand how distributed networks of coordinated work changes over time as new technologies are introduced, something which other groups in formal and informal settings must take into account when engaged in collaborative practice. Drawing on a tradition of massively multiplayer online game (MMOG) ethnography (Taylor, 2006; Steinkuehler, 2007), I studied and played with the player group for ten months (November 2005-September 2006), collecting chat and video data of our gaming sessions, and used discourse and interaction analyses to understand the data.

The new technology or actor was a third-party modification or "add-on" to the game and was first introduced to the WoW gaming community about four months into the study. It was adopted, first slowly then readily over a two-month period, by the group under study, as its services became increasingly clear. It was instrumental in helping the group become efficient and successful with many in-game, coordinated battles against formidable monsters during an activity known as "raiding." Each raiding session consisted of the group fighting the same monsters over and over until they could successfully kill it and move on to the next monster. While we were in the midst of adopting the add-on for these raids, it played only a temporary role in the group's assessment of a specific encounter, the last monster, Ragnaros, in a fiery cave system known as Molten Core (MC). It helped the group by testing and ruling out a possible diagnosis of the problems with the group's strategy. After eliminating that possible diagnosis, its use was no longer necessary, since its original intended role never needed to be filled in the fight against Ragnaros. This paper details how a historically-based network of online gamers was disrupted by a new technology that coincided with unexpected in-game events. The redistribution and renegotiation of group responsibilities done by the network's dynamic, adaptable actors to overcome those events relied on the new technology in innovative, unintended ways.

Mangles, Networks, Assemblages, and Arrangements

Steinkuehler (2006) described the mangle of play as an emergent complex arena of activity with multiple contentious parties attempting to steer what it means to play in certain directions. This is similar to Pickering's (1993) mangle of scientific practice, which described the dialectic of resistance and accommodation that scientists engage in with the natural world, constantly tweaking their instruments and mental models of how the world works when existing measurements produce puzzling results. Both of these concepts about how gaming or scientific practice works come from a view of these practices as existing in specific settings and circumstances. They recognize that authentic practice "in the wild" includes a multiplicity of parts or parties, acting separately yet collectively, such that collective roles and responsibilities that make the practice what it is are distributed across all of them.

In ANT terms, the activity is composed of multiple objects or actors that act upon other actors and the relationships between actors determines what the network of activity—i.e., practice—looks like. The roles and responsibilities within a network of activity are assumed by both human and nonhuman actors. Flattening the setting allows Taylor (2009) to say, "we do not simply play but are played. We do not simply configure but are configured (Akrich 1995; Woolgar 1991)" (p. 6), emphasizing the fact that actors in a network exist in such a way as to be compelled to act or be acted upon.

Threat Management and KLH Threat Meter (KTM)

Each character in WoW matches an archetypal role based on historical precedent in the fantasy role-playing game and MMOG genres. In representation, characters are warriors, priests, rogues, etc., but for the purposes of

the underlying game mechanics, these various hero classes can be roughly categorized into a function-based tripartite consisting of tank, healer, and DPS. Each of these categories has specific duties and responsibilities to carry in a raid battle. Tanks, with their plentiful Health points and massive armor, have to keep the monsters occupied and focused on them while healers continually cast spells, which deplete their Mana (magic points), to make sure the tanks stay alive. DPS (shorthand for damage per second, a way of valuing damage dealers) can then go about actually killing the monsters.

Each category of roles in the tripartite is therefore necessary to be filled for a raid group to be successful. The problem is that a monster generally attacks whomever it deems the most threatening to its survival. If a DPS player hits a monster particularly hard or a healer heals too effectively, the monster can take notice and decide to hit back. Whoever has the monster's attention is said to have *aggro*, and the monster switches targets when players *steal aggro* from others. Tanks can try to prevent this by activating various abilities meant to maintain aggro, while the DPS and healers try to keep their performance at an even, consistent, predictable level without "spikes" that will make the monster take notice. In other words, many of the encounters in WoW, and indeed most MMOGs, are a balancing game where the three roles of the tripartite work to maximize their efficiency while keeping the tanks the focus of the monsters' attention.

The way in which a monster decides who to attack is completely reactionary to the actions of the raid members. One way to think about how the underlying "brain" of the game calculates monster behavior is to imagine that it creates a table that includes a row for each raid member, and in each row is a number that starts off at zero and increases a certain amount every time that particular raider activates an ability. The amount increased depends on the ability. This number is called the *threat level*. One of the jobs of the raiders, then, is to make sure that the tank(s)'s threat level is higher than everyone else's.

When the raid group I studied first started raiding, each member had to internalize his or her threat level and "play it by ear," so to speak. There was no common resource or explicit knowledge of specific numbers associated with specific abilities. In fact, many of the raiders did not know that threat was based on a constant cumulative number. This is important to note: It was surmised that threat was loosely based off of damage dealt, but it was unclear that it was a cumulative count of all damage over the course of a fight, no matter how long that fight lasted. All that was known was that sometimes certain raid members would do too much damage and gain aggro. Raiders knew from experience that some abilities generated more threat than others and had to weigh the abilities' costs against their benefits. Very often, when a player died, it was because he or she stole aggro from the tank(s). That is, he or she misjudged how much threat was being generated and accidentally raised his or her threat to a higher level than the tank(s)'s threat level. If this happened enough times during an encounter, it usually ended up as a raid wipe (when everyone in the raid died).

About five months into the raid's life, when it was working on defeating Ragnaros, the last boss in Molten Core, the raid was in the process of using a new add-on called "KLH Threat Meter" or "KTM." Created by a player named Kenco, KTM kept track of which abilities a particular player used while fighting a monster, how much threat those abilities generated, and then visually displayed that information to that player. What's more, any instance of KTM could talk to other instances of KTM installed on other people's machines and thereby aggregate all of the threat data for all players who had the add-on installed, displaying relational charts of everyone's threat level to each player. This allowed the offloading of human cognition to a nonhuman resource, effectively eliminating much of the guess work that went into *World of Warcraft* threat mechanics.

Using KTM as a Temporary Actor that Diagnosed Problems

KTM's adoption was a slow process and spanned several weeks across multiple in-game zones and different raiding (sub) groups. It was difficult to understand KTM's usefulness without seeing it in action, and, even then, the demonstration would only be convincing if a critical mass of people were using it. At first, Warren, the main tank, learned about it through the *World of Warcraft* forums and add-on communities, but it was still in beta, so many of the raiders did not feel comfortable installing it, initially. On February 26, 2006, two rogues (including me) had decided to test out KTM's usefulness with a fight in yet another raid zone. Without any tanks or healers having also installed it, however, the threat meter was not of much use. After the add-on was officially released on Curse.com on March 1, 2006, another attempt at getting people to try it happened on March 8, when four members had it installed for the MC run. Still, there were not enough instances of KTM to be useful, but players could start to see how including the add-on to the group's network of activity would be useful for fights it was still struggling with. During the following month, most of the MC raid group would install KTM. By April 2, 2006, much of the group was using KTM. Later, on April 28, it was instrumental in helping the rogues diagnose problems the group was having with the fight with Ragnaros.

The group knew how the fight was supposed to work from reading online strategy guides about it. Reading about the fight did not directly translate into successfully enacting the fight, though. It took embodied knowledge—visceral, physical, rhythmic knowledge—coordinated knowledge developed through gaming. To gain this type of knowledge required practice. It took time to get a sense of the groove—the rhythm of well-coordinated action—the group needed to be in.

Unfortunately, for this particular night of raiding, the rogues had not yet experienced the embodied groove of making the fight routine. We knew what was supposed to happen in the Ragnaros fight, yet, for some reason, we kept dying on each of our attempts to kill Ragnaros for the evening. Ragnaros would, once in a while, focus his attention on one of us and hit that player. This resulted in almost instantaneous death for a rogue.

Naturally, the rogues thought that dying meant we had an aggro problem, leading one of them, Roger, to tell the other rogues how to play:

this is a steady high dps fight, no bursting, bursting will get you aggro, in my experiance, anything over 1000 gets rags to say hi to ya unless you are feint everytime its up, and a split second after your burst.

It seems like Roger believed, however, that threat was not an additive measure and that gaining aggro was simply a matter of moment-to-moment damage output. If damage output was ever too high in a particular instant in time (e.g., over 1000), aggro would be gained. This goes against the tests done by Kenco that resulted in his relatively accurate threat meter—accurate because it treated threat as a persistent, cumulative number representing the sum of all threat generated with all abilities used during a particular fight.

After the group's second attempt at killing Ragnaros for the evening, Rand said, "I got aggro on that one. Not sure how, was using the same technique as last time." To this, I replied

so, I have threatmeter on... noticed I wasnt very high up and did a cold blood evis just fine.
I strongly suggest you get the mod... so you can judge how good you are on aggro

This response was indication that aggro was not gained simply by doing burst damage. It is interesting to note that, at this point, I had already enrolled KTM into my personal actor-network, placing my whole trust into this nonhuman actor for certain responsibilities. I knew that my previous practice of keeping the *feeling* of threat in my head was inexact, and I assumed that this blackbox of a tool could do it better than me. KTM, in turn, gave me permission to push the limits of DPS, and it also let me enroll it as evidence for why threat wasn't the rogues' problem.

During the third attempt for the evening, Roger himself gained aggro and died after the first Knockback event, a move where Ragnaros causes everyone within close proximity to be thrown back, forcing them to run back into fight positions. Roger responded to his death with, "lol. he must dump most agg at Knockback. i think i got to him quicker then the tanks." He assumed that Ragnaros reset his threat table when Knockback occurred, thus getting to Ragnaros before a tank meant it would have been easy for a rogue to generate more threat than a tank since he or she had more time to generate threat.

Eventually, on our fourth attempt, it became clear that the rogues were pulling aggro even though they were nowhere near the threat level as the tanks. This was demonstrated when Roger again died after the first Knockback. When Roger used the general raid channel (instead of just commenting to the private rogue channel) to say, "i hit him once. that made no sense," the raid leader, Maxwell, replied with

Roger, they [the tanks] may have been out of position for just a second which is enough for anyone else to get aggro who is in melee range.

Elevating his talk to the larger chat channel elicited new information from Maxwell that further helped the rogues to diagnose the aggro problems. Maxwell was correct. Ragnaros attacked whoever had the highest threat within melee range, and the reason why rogues were being killed was because they were running into position and getting within Ragnaros's melee range before any tanks had gotten in range.

By the end of this gaming session, the rogues *almost* realized that Ragnaros hit whoever had the most threat *within range*. This new information from Maxwell added to the information that I presented to the other rogues in the previous fight from the threat meter add-on, such that, by the time we fought Ragnaros again the following month, we had put it all together and delayed our approach to Ragnaros after a Knockback so that a tank got within melee range first.

By using KTM to see that the rogues' threat level was not high enough to theoretically pull aggro, we had to think of other possible reasons why we were being targeted for attack by Ragnaros. Thus, KTM played a role as a temporary actor within this raid encounter. The group only used KTM to diagnose problems, not to actually alert it of threat level dangers throughout the fight. Once we figured out that threat wasn't the problem, we essentially no longer needed KTM for the Ragnaros fight.

In summary, the raid group I played with had reached Ragnaros by the time the new threat meter add-on KTM arrived on the WoW gaming scene. It took the group several weeks, however, to incorporate KTM into its assemblage of play. It completely changed how the task of keeping track of threat was distributed in the

network. Yet the Knockback events in the Ragnaros fight forced the rogues to reconfigure or renegotiate in-the-moment how KTM was enrolled into the network. It added to our body of evidence that threat was not actually the reason rogues were gaining aggro, and, weeks later, we were able to incorporate this new knowledge into a successful strategy.

The idea that we assigned a new role to KTM in-the-moment may seem to complicate actor-network theory's concept of *delegation* where nonhuman actors are meant to take on specific responsibilities by their creators. Instead, we see that this actor-network was dynamic and the translation process—the negotiation and agreement process—necessitated constant reworking and retranslating. Latour (2005) understood actor-networks as ever-changing, though, which is why the work of the actors within the network leave traces of their associations to be followed and examined and why, once described, the network *as described* may no longer exist.

Discussion and Conclusion

Actor-network theory is an attempt to describe how an arrangement of objects in a network are acting on others and are acted upon by others so that the activity does what it does. It tells a story about practice within situated contexts, involving historically-based interrelated actors. At the basic level, this network ANT describes is an assemblage of parts, but it is also dynamic. This dynamism is what makes it a mangle with vying interests and constantly renegotiated relationships and distributions of responsibilities. The reassembling occurs across multiple layers of complexity and multiple timescales.

On the surface level, the whole landscape of *World of Warcraft* play was determined by designed constraints from the game developers, who were, in turn, affected by the historical evolution of MMOG play. Digging deep, individual players assemble and arrange the objects and resources in their specific in-room, on-screen settings. KTM is just one of these objects.

Between the work that occurred on the surface level and the deeper individual player level lays the mangle that Steinkuehler (2006) wrote about: a messy set of practices emerging from the constant clash and negotiation between the designed experience, players' exploration and meaning-making in that experience, and all the ways in which various parties exploit, modify, and change the system. In the larger WoW community, KTM and other player-created add-ons that helped raids manage raiding was becoming so normative that Blizzard Entertainment was forced to incorporate many of their user interface tweaks into future iterations of the base game.

This raid group and its activity across the locations in which it assembled represent one tiny sub-mess—a microcosm of the mangle—and yet this small mess could be broken down further. Each character class was grouped together and those groups independently assigned internal roles and responsibilities, engaged in scientific argumentation about strategies and tactics, and participated in a larger class-based WoW community. Furthermore, as stated earlier, each player had his or her own local configuration to manage. Just as Stevens, Satwicz, and McCarthy found with their young gamers (2008), these arrangements would sometimes extend beyond the computer screen and into the room.

The enrollment of KTM into the raid's standard practice brings up a number of issues. First, though it was nominally being incorporated to an existing network, it took on a sort of agency itself by imposing new responsibilities to the other actors in the network (e.g., it shifted communication patterns, it drove changes in strategy). Giddings (2007) uses Dennett's (1971) concept of *intentional systems* to describe the key difference between agency ascribed to humans versus nonhumans:

So this intentionality does not assume that complex systems have beliefs and desires in the way humans do, but that their behaviour can, indeed often must, be understood *as if* they did. Or perhaps, and Dennett hints at this, their "beliefs" and "desires" are not so much metaphorical as analogical.

This "unmetaphysical" notion of the intentional system both resonates with Latour's nonhuman delegations and suggests ways in which we might theorise our material *and conceptual* engagement with complex computer-based media, sidestepping a whole range of largely unhelpful speculations on imminent realisation of actual machine consciousness. It suggests that the experience of playing (with) these game/machines be theorised as one of engagement with artificial intelligence without slipping into naive anthropomorphism or frenzied futurology (p. 122).

KTM, on a micro level, required players to give it attention and then adjust behavior based on what it displayed. It did not care, of course, whether players actually changed their behavior, and neither did it enforce its use. Yet, by being a transparent tool, showing everyone's threat level to all players, it did not need to enforce its use. The raid members did that on their own. This is both good and bad. Its benefit was clear: some of the players appreciated being reminded by others to be cautious about their threat level. Yet this came with a price.

While KTM served as a threat meter add-on to warn us of impending aggro change, it also served as a surveillance tool that we could use to make sure each of us was playing efficiently to help the common task. What used to be monitored individually had become distributed to the collective, making it as open as Thomas More's houses in *Utopia* and as transparent as Bentham's Panopticon. Furthermore, on a more macro-historical level, KTM helped narrow the legitimate experience of playing *World of Warcraft* by reinforcing the threat paradigm and the tank-healer-DPS tripartite found in MMOG encounters. Playing WoW has consistently become more and more a game of numbers, efficiency, and number-crunching, buying into the notion that the end goal of playing is to win loot and progress.

The second issue brought to light in analyzing KTM's adoption is the issue of communication levels. The rogues were internally attempting to make sense of Ragnaros's aggro changes, but it was only after Roger voiced his dissonance in the general raid chat channel that the rogues began to understand what was happening. This occurred when Maxwell replied to Roger, letting him know that the melee DPS needed to wait for tanks to be in position before getting in range. Indeed, it seemed like Maxwell, a non-rogue, already knew about Ragnaros's melee targeting preferences. If it is necessary for group members to make available to others their misconceptions before the group can become aligned or translated to a common understanding, how do individual players become compelled to speak up? The raid assumed character class-specific expertise in all its members. Displaying evidence of a lack of understanding could have been seen as a risky move. What's more, this assumes the rogues could identify and be metacognitive about their lack of understanding and need to elevate their talk from their private rogue channel to the larger raid channel. Yet the onus of opening up appropriate communication channels so the raid could repair itself seemed to be taken up by happenstance through flabbergast and flailing. What do we make of this? In future endeavors or other group work, some way to insure recognition of micro dissonance that needs to be elevated to the whole group would be necessary.

Still, the raid's eventual adoption of a new actor into the network is an example of how local practice is emergent and dynamic and heavily dependent on available technomaterial resources, which are assembled and configured in and around the activity. This example helps us redefine expertise development not as just changes in practice, but also, as changes in how the assemblage is configured, which necessitates the successful negotiation among actors in a network about distributed roles and responsibilities and a shared understanding about the local task at hand. What's more, the shared understanding and the actual roles and responsibilities that need to be distributed also changes over time. The enrollment and translation process reconfigures all involved. The reconfigured network is then stable and successful—that is, until a new disruption occurs.

References

- Akrich, M. (1995). User representations: Practices, methods and sociology. In A. Rip, T. J. Misa, & J. Schot (Eds.), *Managing technology in society: The approach of constructive technology assessment*. London: Pinter Publishers.
- Dennet, D. C. (1971). Intentional systems. *The Journal of Philosophy*, 68(4), 87-106.
- Giddings, S. (2007). Playing with nonhumans: Digital games as technocultural form. In S. de Castells & J. Jenson (Eds.), *Worlds in play: International perspectives on digital games research* (pp. 115-128). New York: Peter Lang Publishing.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Milton Keynes: Open University Press.
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network theory*. New York, NY: Oxford University Press.
- Pickering, A. (1993). The mangle of practice: Agency and emergence in the sociology of science. *American Journal of Sociology*, 99(3), 559-589.
- Steinkuehler, C. A. (2006). The mangle of play. *Games and Culture*, 1(3), 199-213.
- Steinkuehler, C. A. (2007). Massively multiplayer online gaming as a constellation of literacy practices. *E-Learning*, 4(3), 297-318.
- Stevens, R., Satwicz, T., & McCarthy, L. (2008). In-game, in-room, in-world: Reconnecting video game play to the rest of kids' lives. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 41-66). Cambridge, MA: The MIT Press.
- Taylor, T. L. (2006). *Play between worlds: Exploring online game culture*. Cambridge, MA: MIT Press.
- Taylor, T. L. (2009). The assemblage of play. *Games and Culture*.
- Woolgar, S. (1991). Configuring the user: The case of usability trials. In J. Law (Ed.), *A sociology of monsters: Essays on power, technology and domination*. London: Routledge.

Acknowledgments

This work is funded by the National Science Foundation through the Science of Learning Center program under grant SBE-0354453.

Allocentrism and Computational Thinking

Carmen Petrick, The University of Texas at Austin, 1 University Station D5700, Austin, Texas 78712-0379
USA, carmenpetrick@gmail.com

Matthew Berland, The University of Texas at San Antonio, 1 UTSA Circle, San Antonio, Texas 78249 USA,
matthew.berland@utsa.edu

Taylor Martin, The University of Texas at Austin, 1 University Station D5700, Austin, Texas 78712-0379 USA,
taylormartin@mail.utexas.edu

Abstract: IPRO is a virtual programming environment in which students use handheld devices to program virtual robots to play soccer. The mobile nature of IPRO allows students to directly embody their robots, meaning that they physically enact their programs as if they were a robot. The process of direct embodiment prompts students to interpret their program from an egocentric perspective (i.e. the robot's point of view). We conducted a study of high school students using IPRO, and in this paper, we present the case of how one student directly embodied her robot in order to develop her program. We found that the student used direct embodiment in order to make detailed decisions about her program code and that collaborating with teammates and using other resources helped her make general decisions about her program. We also found that the student alternated between allocentric and egocentric frames of reference while developing her program.

Introduction

Between motion-controlled video games, avatar-based social worlds, and ubiquitous mobile devices, high school students have become avid users of recent technological advances. However, when these students enter technology and engineering classrooms, they experience a significant disconnect from the highly collaborative, interactive devices and applications to which they are accustomed. Traditional computer programming instruction focuses on procedural skills, limits collaboration, and puts little emphasis on building conceptual understanding (Pea & Kurland, 1984; Robins, Rountree, & Rountree, 2003). Developments in the last decade have started to bridge the gap between how computer programming is taught and how students experience programming outside of school (Maloney et al., 2004; Wilensky, 1999). Changing the programming environment can alter the way students understand computer science, engage previously uninterested student populations, and change students' perceptions of the field.

IPRO (which stands for "*iPod Robotics*" and "*I (can) program!*") is a virtual programming environment designed to support students in developing computational thinking and programming skills in a social, mobile space. Students use handheld devices (e.g. the iPod Touch) to program virtual robots to play soccer. Rather than holding class in a computer lab, students work in a large open space and are free to move about the room. This setting promotes collaboration and the ability to use physical movements to intuit and interpret program code. Students can imagine they are each a robot, moving ways that a robot might move; we are calling this *direct embodiment* after work by Fadjo, Lu, & Black (2009). When students directly embody their robots and physically enact their programs, they naturally assume the robot's first-person perspective within the program, or what Berthoz (2000) calls an egocentric frame of reference. This point of view transforms the way information about their programs is perceived and interpreted. While it is possible to imagine a first-point of view without physically pretending to be a robot, students learning to program in a mobile environment can directly embody their robots as a way to use an egocentric frame of reference within their programs. As students collaborate with their teammates, they are more likely to transition to an allocentric, or third person, perspective. This paper presents a case study in order to explore in detail how one student's physical movements allowed her to directly embody her robot, easily access an egocentric frame of reference, and combine this with other resources to develop her program.

As research points towards cognition evolving from perception and action (Anderson, 2007; Varela, Thompson, & Rosch, 1993; Wilson, 2002), the connections between physical movement and cognition become clearer (Anderson, 2003; Seitz, 2000; Wilson, 2002). What we see, hear, feel, and do with our bodies helps us to understand and make sense of what is going on around us. Papert (1980) calls this "body syntonicity." He developed Logo and Turtle geometry specifically to draw upon students' understandings of their bodies and to motivate them with authentic problems that they could solve by drawing from their past experiences. He encouraged students to "play turtle" by directly embodying the Logo turtle and acting out the movements that they wanted to program the turtle to make. In our research, we build on Papert's idea of "playing turtle" by examining how, in our case, "playing robot" can help students access multiple frames of reference and advance their thinking. We hypothesize that alternating between frames of reference is important to the development of computational thinking. The research presented here builds upon the ideas of body syntonicity and, more broadly, upon the theories of embodied cognition (Anderson, 2003; Seitz, 2000) to create a mobile-social

programming environment that will facilitate students' abilities to physically embody their robots and enact their programs leading to new learning pathways. IPRO represents one of the many possible ways to help students learn to program through embodiment.

In our larger study, teams of high school students used the IPRO application to program virtual robots on mobile, handheld devices. This paper presents the case of novice programmer, Amelia, learning to program in IPRO. We observed Amelia during one 90-minute class as she attempted to create a robot that would consistently score goals for her team. Using video of her speech and physical movements as well as log data from IPRO, we examined how and why she alternated between the robot's point of view and the overall program view while building her program.

Egocentrism & Allocentrism

Two main frames of reference, egocentrism and allocentrism, are typically used to describe how objects are situated in space (Berthoz, 2000; Klatzky, 1998). In an egocentric frame of reference, objects are understood according to their relationships with the body; while in an allocentric frame of reference, all objects are oriented according to their relationships with each other, and there is no reference to the body. Egocentrism appears to come more naturally than allocentrism since the information the brain gathers has been perceived by the body and comes inherently from a body-centered point of view (Byrne & Becker, 2008). We believe that teaching students to adopt an egocentric perspective when beginning to program would be beneficial to developing a strong programming foundation.

Helping students take a first-person point of view and adopt an egocentric frame is common in education. Wright (2001) suggests that when a student is able to "get inside" a problem, that might help her to understand it more fully. Elementary teachers often reword story problems to include the child's name that they are working with. Even experts employ similar strategies. Physicists transport themselves into a problem by talking and moving their bodies when they interpret graphs (Ochs, Jacoby, & Gonzales, 1994). This same type of entering into a problem and taking on an egocentric frame of reference occurs in programming when the programmer embodies the object being programmed and enacts the each step of the code controlling it. This process of direct embodiment requires changing the frame of reference with which one views the program.

A programmer can think about a program using an allocentric or an egocentric frame of reference. For example, she could view a program from the "top down" by analyzing overall program structure or "bottom up" by evaluating it line-by-line. By adopting the two perspectives, programmers can create more advanced programs (Ackermann, 1996). A programmer may work "inside the program" by evaluating it step-by-step, only returning to an allocentric frame of reference to make major changes to the program. This interchange between "diving-in" and "stepping-out" (as described by Ackermann, (1996) is important for developing conceptual understanding and a natural part of human development (Kegan, 1982). IPRO is designed to encourage this type of interaction. Unlike traditional programming in which students cannot move away from an immobile computer, students can physically carry their programs with them on the iPod Touch as they move. Students dive into their programs as they directly embody their robots adopting an egocentric frame of reference, and collaborating with their teammates helps them to step back out. As students share their ideas with their teammates, they are able to formalize their thinking, usually through an allocentric frame of reference.

Traditional programming instruction does not teach strategies to help beginning programmers adopt multiple frames of reference, often making it difficult to learn to program. Through IPRO, we investigate direct embodiment as one method of helping students adopt an egocentric frame of reference and collaboration as a way of encouraging an allocentric frame of reference. We explore how adopting multiple frames of reference combined with other resources can help students develop more sophisticated programs.

Methods

In this study, 41 students from two classes in an urban high school in the Southwestern United States used IPRO, an application for iOS that supports multi-agent online games of virtual robot soccer. Pairs of students cooperated to create a robot that works with other robots on their team to play soccer against an opposing team. The IPRO language is a visual programming language deriving from Scheme and implementing a simple functional reactive programming paradigm (Cooper & Krishnamurthi, 2006), in that it uses the concepts of signals rather than constants.

Students in the study used IPRO during one 90-minute class. At the beginning of each class, students completed a 5-minute pre-test that included an attitudinal survey and logical reasoning questions. Then they received an introduction to IPRO followed by 15 minutes of guided instruction. After this, students entered the design-compete phase in which they were instructed to collaborate with their team members to design robots for an upcoming match. The classroom they worked in had a large open space in the center with tables and chairs along the edges. Students were encouraged to work standing up in the center of the room in order to promote movement and collaboration. The design-compete phase lasted approximately one hour. During that time,

students could test their robots in solo play, they could share sections of their code with their teammates, and every 10-15 minutes they competed against other teams in match play.

Solo Play: To try out their programs in a non-competitive environment before a match, students could enter their robots into the solo play room. In solo play, the robot and the ball appear on the playing field in random locations, and the robot runs consecutive iterations of the program until a goal is scored or until the student restarts the play.

Match Play: Every 10-15 minutes all students stop working on their programs and enter a match play room. Two pairs of students form a team and compete against another group of students. The class stands in the middle of the room observing a large screen on which the matches are projected. Each match consists of a set number of turns or iterations of the programs.

At the end of the class period, the students took a post-test, which was similar to the pre-test but also included IPRO programming questions.

For this paper, we chose to closely examine the case of how one student, Amelia, attempts to solve one of the first major challenges students face in IPRO—how to program a robot to score a goal when the robot is located between the ball and the goal. We gathered video recordings of Amelia working on this problem, interviews of her while programming, and log data from IPRO of every change she made to her program in the IPRO application. We analyzed her speech, movements, and code at a very fine grain in order to gain a better picture of the role changing frames of reference plays in the programming process.

Amelia's Case

Amelia reported being moderately comfortable with programming but unlikely to pursue a career in a STEM field. The only female in her class of 20 students, she assumed a leading role on her team.

Amelia initially developed a robot that could score whenever it was facing both the ball and the goal (See Figure 1). However, after repeatedly observing her robot in "Solo Play," she determined that it could not score when it was between the ball and the goal. From the transcript, we know that Amelia understood that if the robot found itself between the ball and the goal, then it would have to move around the ball; however, she did not know how to accomplish this.

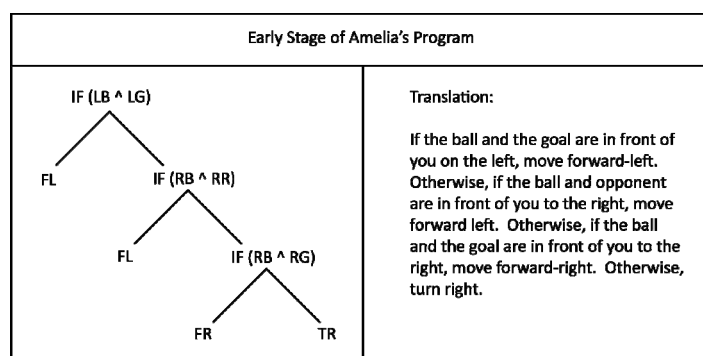


Figure 1. Early Stage of Amelia's Program.

She brainstormed with her partner, Roger, for a while discussing ways to create a robot that could find the ball and then reorient itself on the other side of the ball facing back towards the goal. After they arrived at a basic plan, Amelia stepped away from Roger and began to directly embody her robot (See Figure 2). She raised her eyes up to the ceiling. Then, she looked down at her iPod. Her shoulders made a slight turn to the left and then to the right. Then she turned her entire body 90 degrees to the right and looked down at her iPod. She then turned back to face the front of the class. At this point, she added the last piece of code (trans. into pseudocode as):

```

if (ball-is-forward-right? and opponents-target-goal-is-forward-right?)
  then move-forward-left()
  else turn-right()
  
```

When asked about her movements, Amelia reported that, "I was trying to figure out which way things were turning." Making her body rotate helped her decide the direction the robot should turn. Amelia then shared her changes with Roger and they observed their robot in solo play again to determine how successful the new program was. This small addition created a successful program that would score in 82% of its attempts in solo play. After scoring a goal during the next match, Amelia and Roger resisted making changes to their robot even leading up to the final match. They made slight modifications to the program a few times, but always reverted back to this program. Even at the end of the design-compete phase, when half of the class worked

together to find the best strategies for their robots, Amelia pushed to keep hers the same. "Guys, can I please leave mine as is?" she asked. "It kind of works." It did work quite well, making a critical save in one match and a steal in another.

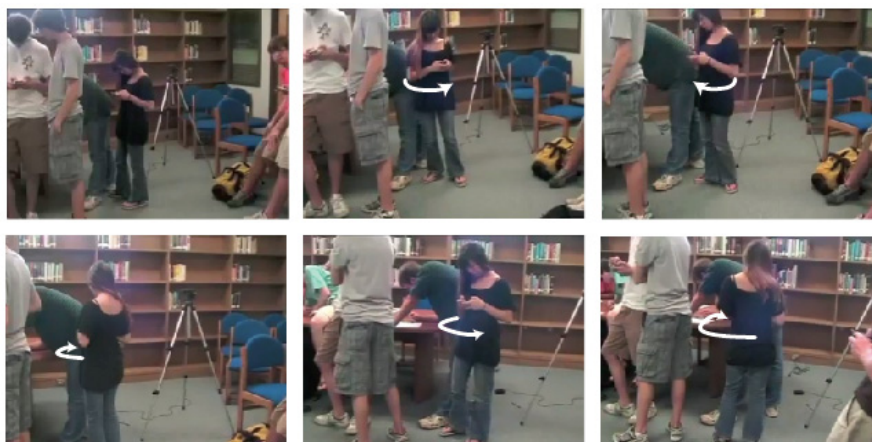


Figure 2. 1) Amelia looks at her iPod. 2) She makes a quick, half turn to the left. 3) She turns back to her original position. 4) She makes a quick, half turn to the right. 5) She returns to her starting position and pauses for a moment. 6) She turns all the way to the right, stays there and adds new code to her program.

Analysis of Amelia

Amelia made use of multiple resources as she programmed her robot. She edited her program code, observed her robot in solo play, directly embodied her robot, consulted with her partner, and evaluated her robot during match play. Amelia used each resource for different purposes. After working with her partner Roger to develop her initial program, Amelia used solo play to determine whether or not her robot was performing the way in which she had intended. She alternated between observing her robot's performance in solo play and the program code view on her iPod. This process allowed her to make connections between the code and the robot's behavior and discover that her robot could not score when it was between the ball and the goal. From her interview, we can conclude that Amelia was thinking about her program from an allocentric frame of reference. She referred to connections between the levels, and she pinpointed where the problem in the code occurred.

After identifying the problem with her code, Amelia and Roger brainstormed possible solutions. Then Amelia began to directly embody her robot to help her make decisions on how to edit her program. She switched from an allocentric to an egocentric frame of reference, as she was interpreting her code from the robot's point of view. While directly embodying her robot, Amelia made several small movements trying out different ideas. Physically acting out the possible directions her robot could turn helped her decide on the correct code to enter into her program.

Amelia then switched back to an allocentric frame of reference as she shared the changes with Roger. Then they watched their robot compete in the next match. Throughout the design-compete phase, they used match play to evaluate their robot, and when their robot scored a goal with the new program code, Amelia resisted modifying the program further.

All of the resources Amelia employed provided different information necessary to improve her program. Amelia switched freely between resources and frames of reference as needed to help her make decisions about her code.

Discussion and Conclusion

Amelia's case suggests that novice programmers could benefit from being taught how to "step in" or directly embody their programs. Directly embodying part of her program gave Amelia a frame of reference "inside" the program, and she used this to make detailed decisions about how to edit her code. She utilized multiple resources and alternated between allocentric and egocentric frames of reference, leading to new understandings of the relationships within the program. Directly embodying a part of a program also provided a way for her to quickly try out different ideas or movements and observe the effects.

Students using IPRO regularly act out their programs in different ways to see which outcome is optimal. Directly embodied actions provide means for students with little programming experience to take on egocentric frames of reference and learn advanced concepts. While one can look back as far as Papert (1980) to find children embodying computer programming, our study provides evidence that students can quickly use embodied cognition in computational thinking with very little guidance or direction. In IPRO, students begin embodying their robots almost immediately to help them plan their programs and communicate with their

teammates. Since the movements of the robot in IPRO all directly correspond to physical actions with which the students are familiar (e.g. move to the forward-right, turn left, see or detect ball, etc.), students can easily act out how their robot should move even before they completely understand how the code works. The connection between the physical and virtual world makes the programming environment more relatable for students.

This could have important implications for computer programming curricula. By altering the programming environment, teachers can take advantage of the affordances offered by direct embodiment. Finding ways to incorporate mobile, collaborative activities in computer science classrooms may make computer science more accessible and more enticing, reaching previously uninterested student populations.

References

- Ackermann, E. K. (1996). Perspective-Taking and Object Construction. In Y. Kafai & M. Resnick (Eds.), *Constructionism in Practice: Designing, Thinking, and Learning in a Digital World* (pp. 25-37). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Anderson, M. L. (2003). Embodied Cognition: A field guide. *Artificial Intelligence*, 149, 91-130.
- Anderson, M. L. (2007). How to study the mind: An introduction to embodied cognition. In F. Santoianni & C. Sabatana (Eds.), *Brain development in learning environments: Embodied and perceptual advancements*. Cambridge: Cambridge Scholars Press.
- Berthoz, A. (2000). *The Brain's Sense of Movement* (G. Weiss, Trans.): Harvard University Press.
- Byrne, P., & Becker, S. (2008). A Principle for Learning Egocentric-Allocentric Transformation. *Neural Computation*, 20, 709-737.
- Cooper, G. H., & Krishnamurthi, S. (2006). *Embedding Dynamic Dataflow in a Call-by-Value Language*. Paper presented at the 15th European Symposium on Programming, Vienna, Austria.
- Fadjo, C. L., Lu, m., & Black, J. B. (2009). *Instructional Embodiment and Video Game Programming in an After School Program*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications, Chesapeake, VA.
- Kegan, R. (1982). *The evolving self: problem and process in human development*. Cambridge: Harvard University Press.
- Klatzky, R. (1998). Allocentric and Egocentric Spatial Representations: Definitions, Distinctions, and Interconnections. *Lecture Notes in Computer Science*, 1404, 1-17.
- Maloney, J., Burd, L., Kafai, Y., Rusk, N., Silverman, B., & Resnick, M. (2004). *Scratch: A Sneak Preview*. Paper presented at the Second International Conference on Creating, Connecting, and Collaborating through Computing, Kyoto, Japan.
- Ochs, E., Jacoby, S., & Gonzales, P. (1994). Interpretive journey: how physicists talk and travel through graphical space. *Configurations*, 2(1), 151-171.
- Papert, S. (1980). *Mindstorms: children, computers, and powerful ideas*. New York: Basic Books, Inc.
- Pea, R. D., & Kurland, D. M. (1984). On the cognitive effects of learning computer programming. *New Ideas in Psychology*, 2(2), 137-168.
- Robins, A., Rountree, J., & Rountree, N. (2003). Learning and Teaching Programming: A Review and Discussion. *Computer Science Education*, 13(2), 137-172.
- Seitz, J. (2000). The Bodily Basis of Thought. *New Ideas in Psychology*, 18, 23-40.
- Varela, F. J., Thompson, E., & Rosch, E. (1993). *The embodied mind: cognitive science and human experience*: Massachusetts Institute of Technology.
- Wilensky, U. (1999). NetLogo. Evanston, IL: Center for Connected Learning and Computer-Based Modeling, Northwestern University.
- Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, 9(4), 625-636.
- Wright, T. (2001). Karen in motion: The role of physical enactment in developing an understanding of distance, time, and speed. *Journal of Mathematical Behavior*, 20, 145-162.

Acknowledgments

We thank Gilbert Slade & Chadwick Wood for their hard work on this project. This work was supported by NSF Grant EEC-1025223.

When a Console Game Becomes CSCL: Play, Participatory Learning and 8-bit home computing in India

Derek Lomas, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213 USA,
derekloomas@cs.cmu.edu

Dixie Ching, New York University, 239 Greene St. Suite 300, New York, NY 10003 USA, dixie@nyu.edu

Christopher Hoadley, New York University, 239 Greene St. Suite 300, New York, NY 10003 USA,
csc111playpower@tophe.net

Kishan Patel, Dhirubhai Ambani Institute of ICT, Gandhinagar Gujarat 382007 India, kishan_patel@daiict.ac.in

Matthew Kam, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213 USA,
mattkam@cs.cmu.edu

Abstract: This paper presents evidence describing how a single player typing game, designed for use on a low-cost (~US\$10) computing platform, was utilized as a computer-supported collaborative learning activity. The group computer interaction was found to consistently induce verbal language experiences that extended the potential educational utility of the highly limited 8-bit computing platform. Building on these experiences, we describe some of the design implications for promoting participatory learning with video games, particularly in low-income households and developing contexts.

Introduction

CSCL (Computer Supported Collaborative Learning) applications have traditionally focused on technologies that directly support person-to-person interaction, mediated by a computer. But CSCL can also broker virtual connections between people outside the system (Hoadley & Pea, 2002) or around the system in a physically shared context (Roschelle & Pea, 2002). As gaming becomes a more important educational technology strategy, we face a similar set of design challenges: games can be designed for individual use, for directly mediated group use, and, importantly, for indirectly mediated group use. We describe how this issue plays out in the widespread but understudied context of 8-bit home computing in developing countries.

Our research team has conducted an investigation of 40 low-income households in two cities in India to understand the design context in which 8-bit games might lead to learning. We then deployed 20 8-bit computers in a subset of these households in order to understand how families learned and used the TVC. In this paper, we describe the appropriation of one game that, although designed for solitary use, in actuality engendered significant collaborative and participatory gameplay. Though our observational data, we argue that designing for developing contexts should take into account the collaborative and group nature of the interaction likely to occur, even for seemingly single-player games.

About the Platform

8-bit TV computers (TVCs) are a popular computing and gaming device found widely in India and other developing world markets. The processing unit is contained within a keyboard; a TV set typically serves as the monitor (see Figure 1). The TVC is sold in India for \$8-25, making it an affordable option among the “emerging middle class,” which, in India alone, comprises over 300 million people with household incomes between \$80-150 per month. The TVC is based on hardware components similar to the 8-bit *Nintendo Family Computer*, or Famicom, which was marketed in the US as the *Nintendo Entertainment System*. It was a popular 1980s-era video game console associated with classic games such as *Super Mario Brothers*. Like the NES system, the TVC uses the 8-bit 6502 microprocessor just like the Apple II, Commodore 64, BBC Micro, and Atari 800.

The TVC is typically sold with two game controllers, a light gun, and two game cartridges, an “education” cartridge and an “entertainment” cartridge. The games on the “educational” cartridge, which includes a few typing games and an alphabet learning activity, are typically of poor pedagogical quality, especially when compared to the 8-bit educational games developed for the Apple II in the 1980s, such as *Number Munchers*, *Where in the World is Carmen San Diego*, *Robot Odyssey* and *Oregon Trail*. In 2009, a volunteer game development community (Playpower.org) was founded to address this content issue, with the rationale that a significant educational impact could be made in these low-income households if pedagogically-sound, culturally-relevant games could be provided for the TVC.

In the winter of 2009, a game design workshop was held in Hyderabad, India, with 12 Indian undergraduate students attending. Participants analyzed historical learning games and learned basic principles of instructional game design; a modified version of the IDEO Human Centered Design (HCD) Toolkit was used to identify appropriate opportunities. Typing skills were identified as a target area, both because of the poor quality of existing typing games currently available on the device and the economic value of typing skills. A storyboard for *Hanuman, Typing Warrior* was developed, based upon a popular tale in the Indian epic *Ramayana*, in which

the monkey-like god Hanuman must travel to a far away mountain in the Himalayas to fetch a life-saving herb for his friend Lord Laxman. After the workshop, game development continued by an international team of volunteer game designers and service learning student programmers in India (see <http://vimeo.com/16327114>).

Successfully completing each level in *Hanuman, Typing Warrior* (Figure 1c) requires the ability to type with increasing accuracy and speed. The player makes Hanuman (1) walk forward by typing the letters of the word; the correctly typed letters are underlined (3) to indicate the next letter to be typed. The first part of the text is consequence free, in that the player is not penalized for slow or inaccurate typing. Once the player begins typing the second word on the screen (4), each correctly typed letter causes Hanuman to strike the monster (2). However, if the player does not type a letter fast enough, the monster strikes back at Hanuman. When Hanuman is hit, he is flung back across the screen and must retype until the player learns to type the phrase well enough to defeat the monster.



Figure 1. The TVC Platform. Figure 1a. Typical packaging; Figure 1b. Children playing an included typing game, Ahmedabad, India; Figure 1c. Annotated screenshot from *Hanuman, Typing Warrior*.

Methods

This paper reports on the results of contextual interviews and field observations of families in a rapid ethnography, contextual design process (Holtzblatt, Wendell, & Wood, 2005; Millen, 2000). After receiving training in ethnographic fieldwork, local students recruited and interviewed 20 lower-middle class families (\$80-\$300/month/household) about existing patterns of technology use and gave each family a TVC. The researchers conducted a follow-up interview after two weeks to understand device use and adoption, then visited a week later to observe how the children played their favorite video games on the TVC. Finally, after the families had possession of the TVC for approximately 4 weeks, an extended (90-180 minutes) game observation session was conducted with 14 of the 20 families. A significant portion of the game observations was spent observing how the families played *Hanuman, Typing Warrior*.

The purpose of the research was descriptive, specifically to identify key contextual constraints and affordances in the use of Playpower games on the TVC platform. Tapes of family interactions with the hardware were transcribed and analyzed. Although these prototype games were designed with individual play in mind, the data clearly showed how the games were, in fact, appropriated such that they were played collaboratively. Below, we describe some of the evidence showing how one Playpower game afforded collaboration and discuss some of the design implications of the collaborative use of the game in this context.

Results and Discussion

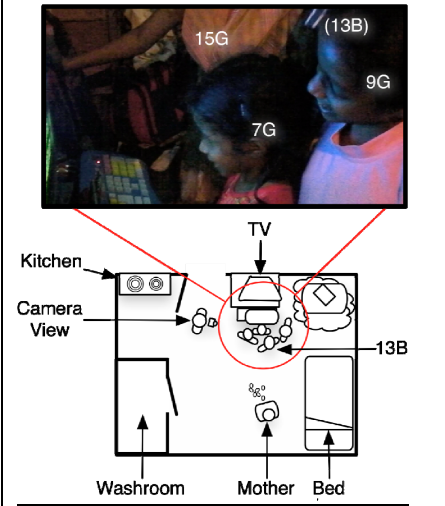
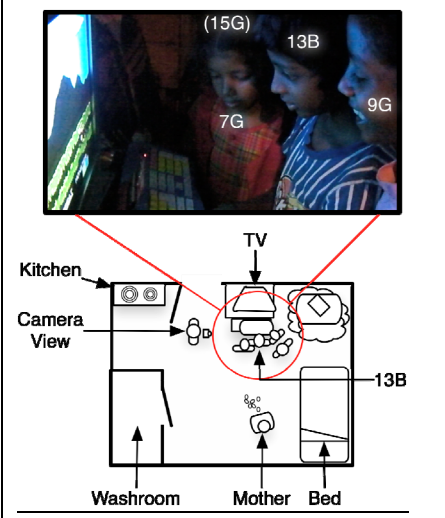
In general, we observed a wide range of group activities emerge around the playing of these video games; these group activities appeared sometimes to enhance the player's learning and sometimes to impede it (though often as a result of another audience member who took over playing). Below, we describe one case in detail, and describe a range of other structures of participation observed across all the families. We then consider the motivations for participation and the possible effects of this activity on the learning process.

Our example case occurs in a household in which both parents worked (household income of ~US\$80/mo.) in order to support their five children ranging in age from one to fifteen. All but the youngest of the children were in school, and two daughters had a fair grasp of English. The introduction of the device had some impact on family dynamics: in the initial interview, the father reported little interaction with his children, but after the introduction of the TVC he described how he enjoyed playing videogames with his son and daughters after work. While the father and son had priority, the three girls also played regularly after school. The mother, however, expressed a fear of breaking the device and did not use it, nor did nonfamily members.

Below (see Table 1) is an activity transcript of 40 seconds of game use filmed by the researchers. The participant codes reflect age and gender (e.g., 7G is the seven-year old girl). As the following transcript illustrates, the children collaborate on the typing task and not only align their attention to the progress of the player

in the game, they distribute the work across multiple people, compete for the computer resource, scaffold each other, and generally construe the task of playing the video game socially. In this transcript, the children are trying to quickly type a phrase as it appears on screen before a monster is able to strike their game character.

Table 1: Transcript of one *Hanuman, Typing Warrior* game session from Household BC.

<p>The images below show the physical positions of the participants in their home, over the course of the play session.</p>	<p>Context: A 7-year-old girl (7G) is playing <i>Hanuman, Typing Warrior</i> with her siblings. Her two older sisters (9G and 15G) and older brother (13B) are looking on and helping her play. 9G had been playing for 5 minutes previously, but had reached a challenging stage where, due to slow typing, a monster was able to strike her game character, Hanuman. As the phrase of words had to be retyped, 9G deferred to her younger sister 7G, who wanted to play. Their older brother (13B) also wants to play. The following sequence shows the cooperative and competitive interactions occurring between the primary player and the surrounding participants.</p>
<p>0 Seconds:</p> 	<p>0 Seconds <i>The words "DEFEAT MONSTER" are presented on the screen.</i> 7G: Looks at screen then looks down and presses D on the keyboard. As she looks back up at the screen, she says "D". 7G: Looks back down at the keyboard and presses E. Says "E." 7G: Looks up at screen. Says "F," then looks down and presses F. 9G: Says, "E... E," 7G: While looking down, presses E. Then looks up and scratches head. Says "E," then looks down at keyboard. 13B: Says "A" as she reaches over 7G's shoulder towards the keyboard.</p> <p>10 Seconds 7G: Presses A and then looks up. Says "A," then looks down. 7G: Presses T, looks up and says "T". Looks down again. 9G: "M." 13B: "M." 7G: Presses M. As she looks up, she says "M," then looks down. 13B: "O." 7G: Looking down, presses O and says "O." Presses N, then looks up. Says "N" and looks back down. 13B: "S." 9G: "S." 7G: Presses S but it doesn't work. Looks up, says "S" and looks down. 9G: "T." The snake reaches out and strikes the Hanuman character. 9G: "Noo..."</p>
<p>40 Seconds:</p> 	<p>22 Seconds: <i>7G's older brother 13B moves into the space by the keyboard, while 7G steps to the side. 13B begins to type, with index fingers of both hands extended. The words "DEFEAT MONSTER" are again presented on the screen.</i> 13B: Presses D and says, "D." 7G: "E..." 13B: Says "E," then searches for this button and presses it.</p> <p>30 Seconds: 7G: "F..." 7G puts her finger over the F button but does not press it. 13B pushes down on 7G's finger to press button. 13B: "F." 13B pushes 7G's hand away from the keyboard. 9G: "E" 7G: "E." 7G reaches over and presses E. 13B: "E." 13B looks around then pushes at the air above the keyboard where 7G's hand was. 13B: "A." 9G: "A." 9G: reaches over and presses A. 13B pulls 9G's hand away from the keyboard. 9G tries to press T but 13B pulls 9G's hand away again. 7G: "T, T." 13B: presses T for himself. "T."</p> <p>40 Seconds</p>

The use of this presumably individual technology is actually very much a collaborative learning setting. At a descriptive level, there were numerous types of social-computer interaction that can be identified within this transcript. To begin with, the non-players are clearly engaged in watching the gameplay and the game player's actions. Non-players appear to comprehend the goals and sub-goals presented by the game, such that they respond verbally to the successes and failures in the game. The basic engagement of the audience in a game played by another person is the basis of further participation and collaboration, such as the reading of the letters aloud.

Like many video games, this game created a competitive desire within the audience to dominate the control of the gameplay. This competition for dominance over the device was informally resolved by turn-taking, which typically followed a mistake by the dominant player. For instance, in the minute prior to the transcript, 9G was the dominant player. However, after she failed to type quickly enough to avoid being hit by the monster in the game, she ceded game control to 7G. Then, the transcript shows how 13B quickly moved in to take control after 7G was hit. Non-dominant players can still participate in the game, however, as demonstrated by 9G and 7G when they continued to type letters even after 13B was in the dominance position. In contrast to a game pad, the keyboard is a large enough input device that multiple persons can visually search the space for the correct key at a time.

Interaction patterns observed among home inhabitants using the TVC reflect what has been reported in both formal (Parikh & Ghosh, 2006) and informal learning settings (Dangwal, Jha, Chatterjee, & Mitra, 2005). In low resource environments, individuals often crowd around a single device, with a dominant user at the controls (e.g., keyboard, mouse, gamepad). Such hierarchical dynamics of “sharing” raises issues of inequities in learning, especially with regards to children from poor settings (Pal, Patra, Nedeveschi, Plauche & Pawar, 2009). Several lines of research address how to create more equitable learning environments where limited computing resources do not allow each participant to have his or her own interface. Pal et al. (2009) found that increasing opportunities to interact with the technology was not the sole determining factor in improving learning outcomes; providing motivations to collaborate was also key. Other paradigms for fostering equitable multi-user interaction with interfaces include encouraging peer learning by leveraging personal social networks (Dangwal & Kapur, 2008, 2009) and peer-mediated cooperative learning processes and positive group dynamics (Sahni, et al., 2008; Hoadley, Honwad & Tamminga, 2010). Overall, while many of these studies on learning in developing countries have focused on cooperative learning in formal and informal school-based environments, it is equally important to examine cooperative learning in homes in the developing world, another important nonformal context.

The work of Satwicz and Stevens (2007) can inform our discussion of the cooperative behaviors that we observed during gameplay. In their observations of videogame play in the home among three siblings, they highlight how the individual creates a meaningful collaborative learning environment by shifting elements in his or her “socio-technical learning system” (p. 634) comprising people, games, characters, and actions. Stevens, Satwicz, and McCarthy (2008) go on to argue that these emergent, self-organized “flexible learning arrangements” have educational potential because they lead to opportunities for “sociality, joint projects, and empowerment through sharing one’s knowledge and seeing it used for concrete success by others” (p. 52-3). In particular, this perspective helps conceptualize the most surprising form audience participation in *Hanuman, Typing Warrior*: the audible reading aloud of the letters by the players and the non-players.

Letter reading was a spontaneous activity that was observed in nearly all households, which is notable since the children’s first language does not use the Roman alphabet. Like most players we observed, 7G said the letter aloud while looking back up at the screen, just after she typed it, as though to verbally confirm her action. However, the audience members tended to say the letters before they were typed, as though to help the player know which letter should be typed next. In several instances within the transcript, the non-players are able to alert the player to their typing errors by repeating letters that were not successfully typed. The typing skills in the game are supported by fluency with both the English words and the script used to write them. Even children who are not actively typing could practice letter recognition and articulation. It is important to note that this oral practice is a vital strategy for language acquisition, and while the computer did not directly support this practice, this important learning activity seems to be fostered as an artifact of collaboration with the technology.

In *Hanuman, Typing Warrior*, the player’s attention shifts from screen to keyboard. This conspicuous head motion may signal to the audience the specific goals and challenges facing the player, prompting the assistive response of reading the letters aloud. Because children are known to have a remarkable ability to infer the goals of other people as well as the motivation to spontaneously support those goals (Tomacello, 2008), even game spectators can become valuable learning partners, supporting their peers in a form of a mutual cognitive apprenticeship (Collins, 1991). In contrast to standard groupware interfaces that mediate collaboration directly, we believe further research is needed to understand how to design good CSCL in order to engage spectators both as learners and as learner scaffolds.

Conclusion

An 8-bit computer has a very limited capacity to produce or recognize speech sounds. And yet, during the social gameplay we observed across multiple households, the design of *Hanuman Typing Warrior* was able to consistently induce players to pronounce English letters and to respond to the letters spoken by other children. We view the highly participatory environment that surrounds the TV-computer in small, low-income Indian households as a valuable counter-weight to the inherent limitations of the low-cost, 8-bit device. Because audience members can scaffold a player’s understanding of the software, designers should ensure that the game’s goals are visible and comprehensible to a non-playing observer, since the visible challenge of game

tasks may help encourage audience participation and support. Additionally, by conceiving low-cost devices (such as the TVC) as an opportunity to foster CSCL, designers can help provide cost-effective, culturally compatible supports for learning in underserved communities.

References

- Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, 6-11, 38-46.
- Dangwal, R., Jha, S., Chatterjee, S., & Mitra, S. (2005). A model of how children acquire computing skills from hole-in-the-wall computers in public places. *Information Technologies and International Development*, 2(4), 41-60.
- Dangwal, R., & Kapur, P. (2008). Children's learning processes using unsupervised "hole in the wall" computers in shared public spaces. *Australasian Journal of Educational Technology*, 24(3), 339-354.
- Dangwal, R., & Kapur, P. (2009). Learning through teaching: Peer-mediated instruction in minimally invasive education. *British Journal of Educational Technology*, 40(1), 5-22.
- Hoadley, C., Honwad, S., & Tamminga, K. R. (2010). Technology-supported cross-cultural collaborative learning in the developing world. In P. Hinds, A.-M. Soderberg, R. Vatrappu, T. Ishida, M. Maznevski & G. M. Olson (Eds.), *Third International Conference on Intercultural Collaboration* (pp. 131-140). Copenhagen: Association for Computing Machinery.
- Hoadley, C., & Pea, R. (2002). Finding the ties that bind: Tools in support of a knowledge-building community. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. 321-354). New York: Cambridge University Press.
- Holtzblatt, K., Wendell, J. B., & Wood, S. (2005). *Rapid contextual design: a how-to guide to key techniques for user-centered design*. San Francisco: Elsevier/Morgan Kaufmann.
- Millen, D. R. (2000). *Rapid ethnography: time deepening strategies for HCI field research*. Paper presented at the Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques, New York City, New York, United States.
- Pal, J., Patra, R., Nedeveschi, S., Plauche, M. & Pawar, U.S. (2009). The case of the occasionally cheap computer: low-cost devices and classrooms in the developing world. *ITID: Information Technology and International Development*. Cambridge, MA: MIT Press.
- Parikh, T., & Ghosh, K. (2006). Understanding and Designing for Intermediated Information Tasks in India. *IEEE Pervasive Computing Magazine*, 5(2), 32-38.
- Roschelle, J., & Pea, R. (2002). *A walk on the WILD side: How wireless handhelds may change CSCL*. Paper presented at Computer Support for Collaborative Learning (CSCL), Boulder, CO.
- Sahni, U., Gupta, R., Hull, G., Javid, P., Setia, T., Toyama, K., & Wang, R. (2008). *Using digital video in rural Indian schools: A study of teacher development and student achievement*. Presented at Annual meeting of the American Educational Research Association, New York, NY.
- Satwicz, T. & Stevens, R. (2007). Tools of play: coordinating games, characters, and actions while learning to play video games. In *Proceedings of the 8th International Conference on Computer Supported Collaborative Learning* (pp. 633-642). New Brunswick, NJ.
- Stevens, R., Satwicz, T., & McCarthy, L. (2008). In-Game, In-Room, In-World: Reconnecting Video Game Play to the Rest of Kids' Lives. In K. Salen (Ed.), *The Ecology of Games: Connecting Youth, Games, and Learning*. The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press.
- Tomacello, M. (2008). *The Origins of Human Communication*. Cambridge, MA: The MIT Press.

Acknowledgments

We gratefully acknowledge the participation of the families in Ahmedabad and Bangalore in this research, which was funded by a "Digital Media and Learning" award from the MacArthur Foundation, the HASTAC digital collaboratory, the CMU HCI Institute, and a grant from the IES PIER program.

Student Game Development Team: Revoori Vishvesh, Vivek Fitkariwala, Kishan Patel, Parth Rao, Ankit Patel, Dheeraj Medikonda, Darsh Shah, Yash Soni, Anshul Pahwa.

Student Fieldwork Team: Aliya Pabani, Alisha Panjwani, Tanvi Srivastava, Pranav Patadiya, Parth Rao, and Sonali Dubey. Field Research Training: Meera Lakshmanan. Additional thanks to all the Playpower.org volunteers and the #NESDEV community, in particular Don Miller (NO CARRIER). Game graphics by Jeremy Galante and Alex Bond (ENZO).

Emerging Tensions in the Future of Technology-Enhanced Learning: First Results of an International Delphi Study

Celia KAENDLER, Christine PLESCH, Anne DEIGLMAYR, Dejana MULLINS, Institute of Psychology,
University of Freiburg, Germany,

Email: kaendler@psychologie.uni-freiburg.de, plesch@psychologie.uni-freiburg.de,
deiglmayr@psychologie.uni-freiburg.de, mullins@psychologie.uni-freiburg.de

Nikol RUMMEL, Institute of Education, Ruhr-University Bochum, Germany, nikol.rummel@rub.de
Hans SPADA, Institute of Psychology, University of Freiburg, Germany, spada@psychologie.uni-freiburg.de

Abstract: In this paper, we present results of an international Delphi study on technology-enhanced learning (TEL). The 5-round Delphi study is carried out as part of the European Network of Excellence STELLAR. This article focuses on the results of the 2nd Delphi round, in which 230 global experts in the field of TEL evaluated, as part of a more extensive questionnaire, visionary statements on TEL that had been identified in the previous round. Experts rated each statement's desirability as well as its likeliness to become reality by 2025. Statistical analyses yielded seven types of visionary statements and revealed possible areas of tension within TEL and TEL research in the future. To conclude this article, we lay out the implications of the results and give an outlook on the next rounds of the STELLAR Delphi study.

Introduction

The prevalence and the capabilities of *information and communication technologies* (ICT) in educational settings have sparked the interest of researchers in technology-enhanced learning (TEL) in last decades. In the past, forecasting the future of TEL has been in the focus of several studies such as the annual Horizon Report by the New Media Consortium (2010). The present study particularly aims at identifying trends and visions for TEL in order to create a catalogue of recommendations for future TEL research. We employed the Delphi method that allows for surveying a large panel of experts to identify emerging trends and future developments in a given field (Linstone & Turoff, 1975; Rowe & Wright, 1999). In general, Delphi studies involve several rounds of surveys among experts that build on each other. The results of each round are analyzed and transferred into materials to be processed and evaluated by the survey participants in the subsequent rounds.

The Delphi study presented in this paper is embedded in the European Network of Excellence STELLAR (Sustaining Technology Enhanced Learning LARge-scale multidisciplinary Research, <http://www.stellarnet.eu/program>). The STELLAR Delphi study is composed of five rounds; two large global survey-rounds among TEL experts from outside the STELLAR network and three rounds that are conducted within the STELLAR network. In the 1st Delphi round, experts generated future trends in TEL research and visionary statements on future developments in TEL (Plesch et al., 2010). This paper focuses on the 2nd Delphi round, that is, the first of two global expert survey-rounds in which the results of the 1st Delphi round were discussed and evaluated. More specifically, we examine the experts' ratings of visionary statements for TEL concerning the likeliness that these will become reality, and how desirable this would be. The combined analysis of the ratings on both scales for each statement revealed specific patterns in the expert answers. While some statements were perceived as either little or very realistic/desirable by most of the experts, other statements yielded heterogeneous ratings, in other words, people disagreed on the likelihood and desirability of these visions to come true. The mixed patterns suggest tensions inherent in these visions. In addition, we analyzed the experts' comments on the visionary statements that either confirmed the ratings or revealed additional tensions that were not visible from the overall ratings. The identification of tensions in TEL can encourage future research, boost new technological developments, and provide further insights in recurrent TEL-related debates within the research community and the society.

Method

We asked 511 experts in the field of TEL (researchers, developers, policy-makers, practitioners, and business people) to participate in the 2nd Delphi round. Expert status was based either on nomination by one of the STELLAR partners or on membership in the program committee of TEL-related conferences. Out of the 230 global experts who answered the survey, 172 worked in European countries, 52 experts worked outside Europe (Asia, North and South America, Australia), and six experts did not provide information about the country they worked in.

The experts answered an online questionnaire that encompassed closed- and open-ended items: closed-ended rating items on future trends and visions in TEL and TEL research and open-ended items for comments, feedback, as well as personal opinions. This paper concentrates on the closed-ended questions that incorporated

a selection of visionary statements identified in the 1st Delphi round (Plesch et al., 2010). The data collection and analysis took place from February to May 2010.

Figure 1 illustrates the format of the visionary statements used in the 2nd Delphi round. A visionary statement portrays a fraction of a future scenario within the time frame of 15 years. The evaluation of the visionary statements by the experts is employed to identify visions and trends for the future of TEL. The selection of visionary statements used in the 2nd Delphi round was based on statements generated by STELLAR members in the 1st Delphi round. Out of the 134 visionary statements produced by the panelists in the 1st Delphi round, we identified a sample of 16 visionary statements (see Table 1) that included those visions that had been mentioned by several experts and that covered the most important future trends in TEL that other parts of the 1st Delphi survey had identified (Plesch et al., 2010). The experts rated the likeliness of the statement to become reality within the next 15 years and the desirability for each of the 16 visionary statements on a 5-point Likert scale ranging from *unrealistic* (1) to *realistic* (5) and from *undesirable* (1) to *desirable* (5) (see Figure 1).

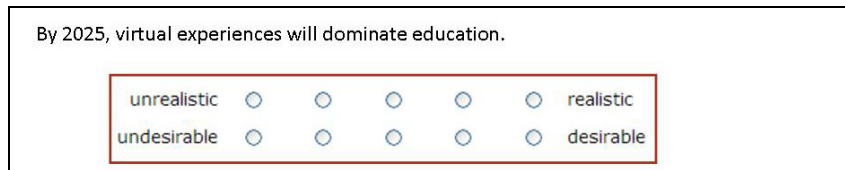


Figure 1. Questionnaire of the 2nd STELLAR Delphi Round – Format of the Visionary Statements.

Data Analysis

In analyzing experts’ responses to the 16 selected visionary statements, we first of all aimed at detecting patterns within the ratings on both rating scales. In particular, we were interested in the homogeneity versus heterogeneity in experts’ opinions: How uniformly would experts rate a given visionary statement with regard to its likelihood to become reality and its desirability? Relevant tensions in TEL would manifest themselves in dispersed distributions of experts’ answers, whereas homogenous opinions would manifest themselves in distributions of answers that would be heavily skewed towards a certain position. In addition, the experts’ written comments on the visionary statements were qualitatively analyzed for additional information indicating tensions in TEL.

A repeated-measure ANOVA revealed that the expert ratings of the 16 visionary statements varied significantly for the different statements; realistic-rating items: $F(1, 14.01) = 62.97, p < .001, f = .55$ and desirability-rating items: $F(1, 13.37) = 199.08, p < .001, f = .99$. The descriptive parameters median, skewness, mean, and standard deviation (see Table 1) further illustrate the differences between the rating-items. The median score is the value that separates the upper and lower half of the sample. The skewness scores indicate if the distribution of the ratings is skewed to either side of the scale. A skewness score smaller than 0 signifies a distribution that is skewed to the right hand side; a skewness score above 0 describes a distribution that is skewed to the left hand side. Based on these descriptive parameters, we revealed patterns within the experts’ ratings on the two rating dimensions *realistic* and *desirability* across the 16 statements.

		Desirable				
		undesirable	mixed	desirable		
Realistic	realistic					
				Type 1 10, 11, 14, 16		
	mixed			Type 4 6	Type 3 4, 8	Type 2 9, 15
			Type 6 1, 3, 5, 7	Type 5 2, 12		
unrealistic		Type 7 13				

Visionary Statements – Types Resulting from the Distribution Patterns.

Four patterns of distributions on the two dimensions *realistic-* and *desirability-rating* across the 16 statements were identified: *very realistic/very desirable*, *realistic/desirable*, *mixed realistic/mixed desirable*, and *unrealistic/undesirable*. We classified the rated visionary statements based on a median score of 3.0, over 3.0, or smaller than 3.0, and a skewness score of 0, larger than 0, or smaller than 0. A median score over 3 and a skewness score smaller than 0 indicate that the ratings are skewed to the right hand side of the scale; the respective visionary statements were therefore classified as the patterns *very realistic/very desirable* and *realistic/desirable*. In contrast, a median score smaller than 3 and a skewness score over 0 indicate that the ratings are skewed to the left hand side of the scale; visionary statements with such a rating were therefore classified as *unrealistic/undesirable*. The remaining distributions were classified as the pattern *mixed realistic/mixed desirable* indicating a wide range of different views on these statements. The 4 x 4 grid in Figure 2 illustrates the 16 possible types of frequency distributions that result from the combination of the two dimensions. In our data, only seven types were detected (for the classification of the visionary statements, see Figure 2). While the ratings for types 1, 2, 3, and 7 were quite homogenous, indicating high agreement amongst experts, the mixed patterns in the types 4, 5, and 6 suggest emerging tensions in TEL. For the purpose of this paper, we therefore particularly concentrate on the latter and merely summarize the homogenous types.

Table 1: 16 visionary statements (MD denotes median, V skewness, M mean, SD standard deviation).

Item	Questionnaire Items of the 2 nd Delphi Round	Scale	MD	V	M	SD
1	By 2025, virtual experiences will dominate education.	realistic	3	0.03	2.88	1.17
		desirable	2	0.27	2.43	1.11
2	By 2025, formal education of long running mass programmes will become irrelevant in favour of networked and digitally supported personal learning trajectories.	realistic	3	0.04	2.88	1.16
		desirable	3	-0.18	3.15	1.27
3	By 2025, learning to type-write will replace learning to hand-write in early education.	realistic	3	-0.12	3.09	1.30
		desirable	2	0.59	2.28	1.18
4	By 2025, recognizing prior learning will be standard and technology plays a vital role in supporting both learners and assessors in accrediting what has been informally learnt.	realistic	4	-0.51	3.57	1.03
		desirable	4	-0.84	3.95	0.95
5	By 2025, no content needs to be memorized because wearable context-aware devices will provide the relevant information.	realistic	3	0.20	2.70	1.30
		desirable	2	0.90	2.07	1.13
6	By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes.	realistic	4	-0.45	3.42	1.22
		desirable	3	-0.06	3.00	1.21
7	By 2025, key developments in TEL will mainly come from the gaming and entertainment industry.	realistic	3	-0.28	3.23	2.32
		desirable	2	0.21	1.13	0.95
8	By 2025, learners will no longer use a mouse or keyboard, but will interact with their computer only using eyes, hands and their brain.	realistic	4	-0.45	3.33	1.24
		desirable	4	-0.47	3.52	1.10
9	By 2025, learners will be empowered to design their own think tools	realistic	4	-0.54	3.30	1.17
		desirable	4	-0.92	4.01	1.02
10	By 2025, intelligent software will support learners to filter information for quality and importance.	realistic	4	-1.15	4.03	1.03
		desirable	4	-1.26	4.11	1.09
11	By 2025, inexpensiveness and ease of use of technology will enable diverse groups of people to access educational resources.	realistic	4	-1.03	4.03	1.03
		desirable	5	-2.12	4.77	0.50
12	By 2025, students will start their school day by switching on their computer and logging in to "school" (from wherever they are at that time).	realistic	3	-0.42	3.37	1.31
		desirable	3	0.09	2.83	1.30
13	By 2025, microchips in our brain and drugs will allow us to control our mood, our motivation for learning and many other emotional aspects.	realistic	2	0.54	2.27	1.21
		desirable	1	2.20	1.37	0.76
14	By 2025, students' report cards will include assessment of domain-general skills, such as computer-literacy, collaboration skills, mastery of reading and learning strategies....	realistic	4	-0.92	3.94	1.06
		desirable	4	-0.76	3.76	1.16
15	By 2025, the boundary between formal and informal learning will have been blurred.	realistic	4	-0.83	3.73	1.12
		desirable	4	-0.94	3.92	1.07
16	By 2025, students will be allowed to use technological devices in exams that are designed to assess students' abilities and knowledge while taking into account what the technological devices can do (e.g. draw graphs...).	realistic	4	-1.51	4.27	0.87
		desirable	4	-1.04	4.20	0.85

Results

Emerging Tensions (Type 4, 5, and 6; VS 1, 2, 3, 5, 6, 7, and 12)

The experts' evaluations of the visionary statements that fall under type 4, 5, or 6 showed mixed results in the realistic- and/or desirable-ratings. The disagreement in the ratings points towards emerging tensions in TEL.

For the statement classified as type 4 (realistic and mixed desirable), experts agreed that the development would quite certainly become reality in the future, but did not agree on whether its consequences would be desirable or not. This statement (VS 6) refers to the recording of the personal learning history and touches on issues of data privacy and security: "By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes". Some of the experts' comments illustrate the mixed ratings on the desirability scale by calling attention to the privacy issues associated with personal track records:

"While the social software of the present is used to construct a kind of relatively public online history (e.g. Facebook), people will still value (and maybe come to value more) experience which is not observed by systems, not recorded, and not available to others."

Thus, the issue of data privacy in the context of data storage for TEL purposes represents a first tension in TEL.

For two of the statements, experts did neither agree in their desirability ratings nor in their realistic ratings (type 5 – mixed realistic/desirable). Both visionary statements address issues of TEL in formal education: "By 2025, formal education of long running mass programmes will become irrelevant in favour of networked and digitally supported personal learning trajectories" (VS 2), and "By 2025, students will start their school day by switching on their computer and logging in to 'school' (from wherever they are at that time)" (VS 12). The first statement stresses individualization and personalization of learning in higher education, whereas the second statement focuses on changes in K-12 education due to the adoption of technology. Both statements portray ratings that are distributed among all options almost evenly. The experts' comments provided insights in the reasons for their ratings. For example, one expert pointed out that the integration of technology into formal education in the suggested way has consequences beyond improving or hindering learning:

"Schools have important roles that are related to the direct interactions of the students and their teachers." (Comment on VS 12)

Thus, both the results from the rating analysis as well as the additional comments by the experts point towards two tensions in TEL: The complexity of the subject at hand and of the learning processes might compromise the implementation of personalized learning trajectories; the adoption of new digital tools for learning into the classroom to enable new methods of learning such as personalized or computer-supported collaborative learning may have both positive and negative consequences for formal education.

For several statements experts agreed that they described undesirable trends; however, there was no consensus as to how realistic these undesirable trends were (type 6 – mixed realistic and undesirable). Visionary statement 5 ("By 2025, no content needs to be memorized because wearable context-aware devices will provide the relevant information") animated the experts to think about which skills and abilities learners will have to master and which skills will be offloaded to a technological tool. The statement suggests that technology will be incorporated in everyday objects and will help the learner to receive tailored information about his/her surroundings. The experts differed in their evaluation of how likely this trend would become reality in the future. Further analysis of the experts' comments revealed the low ratings on the desirability dimension to be due to the importance of prior knowledge for learning. In summary, both the results of the ratings as well as the additional comments point towards a tension in TEL: the role of ubiquitous, mobile learning in the light of the acquisition of complex thinking skills and reflected learning experiences.

Homogeneous Trends (Type 1, 2, 3, and 7; VS 4, 8, 9, 10, 11, 13, 14, 15, and 16)

The statements that fall under types 1, 2, 3, and 7 show clear trends in the expert answers considering the quantitative results. Two statements were considered to be both very realistic and very desirable by most experts (type 1). One statement concerns future visions on the use of TEL for assessment purposes in formal educational settings: "By 2025, students' report cards will include assessment of domain-general skills, such as computer-literacy, collaboration skills, mastery of reading and learning strategies" (VS 14). The second visionary statement that was rated as both very realistic and very desirable (type 1) deals with the topic of social justice that had also been judged as one of the most important research themes in the future of TEL (Plesch et al., 2010): "By 2025, inexpensiveness and ease of use of technology will enable diverse groups of people to access educational resources" (VS 11). The frequency distribution of the desirability-rating for this statement bears an outstanding characteristic: this statement was rated as most desirable with 80.5 % of the experts providing the highest rating score possible (5).

Statements that were classified as type 2 or type 3 showed a drop on the last rating option for one or both rating scales. Thus, these statements were still rated as realistic and desirable, but with less extreme ratings.

For example, the experts agreed on the high desirability of individualization and personalization in the design and adaptation of technology to individual preferences or needs (VS 9: “By 2025, learners will be empowered to design their own think tools”). Another statement that was rated as both realistic and desirable deals with the connection between formal and informal learning. Two thirds of the experts viewed the blurring of boundaries between formal and informal learning as very desirable and also expected this to become reality by 2025 (VS 15: “By 2025, the boundary between formal and informal learning will have been blurred”).

In summary, experts were optimistic about the future of TEL; many visionary statements were rated as both desirable and realistic. These statements covered aspects of fruitful use of technology in formal and informal education, and an expected increase in social justice due to the increasing availability of TEL tools. There was only one statement that was judged to be both unrealistic and undesirable (type 7): “By 2025, microchips in our brain and drugs will allow us to control our mood, our motivation for learning and many other emotional aspects” (VS 13). The experts rejected this statement the most in terms of desirability compared to the ratings of the other statements.

Despite the experts’ agreement concerning the visionary statements of type 1, 2, 3, and 7, the analysis of the qualitative data, that is, the comments on the visionary statements, uncovered further issues underlying some of the visionary statements that were not apparent from the aggregated statistical measures. One of these underlying tensions can be exemplified for the visionary statement 11 dealing with social justice and the digital divide (see above). Despite the extremely high ratings on both dimensions for this visionary statement, some experts were still hesitant about the actual influence and role of TEL in enabling diverse groups of learners to access educational resources:

“Learners are not homogeneous and all exist on one side or the other of multiple digital divides, furthermore new technologies create new digital divides.”

Discussion and Outlook

The presented results of the 2nd Delphi round uncover conflicting positions and opinions held by experts in the field of TEL. The experts’ evaluations of the visionary statements that fall under type 4, 5, or 6 showed mixed results in the realistic- and/or desirable-ratings, which point towards controversial views on these topics among the experts. The analysis of the qualitative data, that is, the comments on the visionary statements, uncovered further issues that indicated underlying tensions.

We elaborated these issues and defined five *Areas of Tension* all of which present two opposing views on a future development in TEL. The first Area of Tension opposes the personalization of learning through data tracking to the related data privacy issues. The second Area of Tension opposes individualized learning paths to standardized learning paths, taking into account the issues of accreditation and assessment. In the third Area of Tension the disadvantages and advantages of introducing innovative technology into the classroom at an early stage are weighed against the reliance on approved practices. The fourth Area of Tension contrasts ubiquitous learning opportunities from focused and critical processing of information. The last Area of Tension raises the question whether the observed technology spread will really help to overcome the digital divide in the future. The identified *Areas of Tension* were refined and extended in the realm of two workshops held with STELLAR partners in summer 2010. In a second global Delphi round, we aim to further explore the underlying issues for future TEL research by presenting the identified Areas of Tension as part of a more extensive survey. The results and conclusions of the STELLAR Delphi study concerning the Areas of Tension will promote the comprehension of the tensions which will play an important role in the future of TEL.

References

- Linstone, H. A., & Turoff, M. (Eds.) (1975). *The Delphi method: techniques and applications*. Reading, UK: Addison-Wesley.
- New Media Consortium. (2010). *The Horizon Report 2010 Edition*. Austin, TX: The New Media Consortium.
- Plesch, C., Jansen, M., Deiglmayr, A., Rummel, N. Spada, H., Heinze, N., & Cress, U. (2010). Opinions on future research themes for technology-enhanced learning (TEL): A Delphi study. In S. L. Wong et al. (Eds.). *Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education*.
- Rowe, G., & Wright, G. (1999). The Delphi technique as a forecasting tool: issues and analysis. *Journal of Forecasting*, 15(4), 353-375.

Acknowledgements

We would like to thank all experts who participated in the 2nd Delphi round and our STELLAR partners who have been supporting us in all stages of the STELLAR Delphi study. The study is funded under the grant agreement no. 231913 of the Seventh Framework Programme of the European Commission (FP7).

An Integrated Approach for the Enactment of Collaborative Pedagogical Scripts Using Mobile Technologies

Marcelo Milrad, CeLeKT, Linnaeus University, Växjö, Sweden, marcelo.milrad@lnu.se
Dan Kohen-Vacs, Holon Institute of Technology, Israel, mrkohen@hit.ac.il
Bahtijar Vogel, CeLeKT, Linnaeus University, Växjö, Sweden, bahtijar.vogel@lnu.se
Miky Ronen, Holon Institute of Technology, Israel, ronen@hit.ac.il
Arianit Kurti, CeLeKT, Linnaeus University, Växjö, Sweden, arianit.kurti@lnu.se

Abstract: This paper describes our current efforts that combine the potential and affordances of two approaches and systems aiming to provide educators and researchers with the ability to design and enact pedagogical scripts to support collaborative learning activities to be conducted in classrooms and outdoors settings. We present and explain how the different technical features of our systems have been integrated combining web-based solutions and mobile applications. One illustrative scenario is described and discussed in order to get a better understanding of the different aspects and outcomes resulting from the integration of our approaches. Our initial results indicate the potential benefits of our approach in order to support and orchestrate collaborative learning trajectories across different contexts.

Introduction

Technological advancements in mobile computing and wireless communication offer the potential for a new phase in the evolution of technology-enhanced learning (TEL), marked by a continuity of the learning experience across different learning contexts. Chan et al., (2006) use the term “seamless learning” to describe these new situations. These scenarios include learning individually, with another student, a small group, or a large online community, face-to-face or in different modes of interaction and at a distance in places such as classrooms, outdoors, parks and museums. Recent examples of such scenarios using mobile technologies can be characterized by emerging patterns of interaction and classroom dynamics that may support learning in many ways: they connect the classroom to the outside world (Liu et al., 2008; Vavoula et al., 2009), facilitate social learning process (Liu & Kao, 2007; Zurita & Nussbaum, 2007), and contextualize the learning experience (Hsi, 2003; Vogel et al., 2010). This wide spectrum of different learning scenarios allows for the creation and design of new possibilities to augment learning.

Spite all these promising developments, there is still a need to improve our knowledge in this field in order to better support the pedagogical design of “seamless learning” tasks and it is necessary to further investigate how students interact with learning contents, peers, teachers and parents through a variety of technologies and contexts. Another challenge is to provide teachers and educators with a set of flexible authoring tools that will allow them to orchestrate these kinds of collaborative learning activities that may take place beyond the classroom. An additional important issue that needs to be addressed in “seamless learning” scenarios relates to the constraints of different systems and technologies that rely on the use of various standards for data exchange what makes the development of interoperable applications a challenging task. Interoperability in these settings would enable multiple applications to interact and seamlessly share data (Vogel, Kurti, Spikol & Milrad, 2010).

Current efforts in the field of CSCL address those aspects related to the integration of collaborative activities that combine digital and physical spaces in which teachers need to orchestrate a wide variety of activities supported by diverse tools (Dillenbourg et al., 2009). Although it can be claimed that CSCL supports the design of learning activities and the introduction of different types of interactive tools to support collaborative learning, most of the research efforts in CSCL have been focused on collaborative activities in classroom settings using different devices such as handhelds, interactive whiteboards, and tabletop interaction systems (Liu & Kao, 2007, Dillenbourg & Jermann, 2010, Zurita and Nussbaum, 2007). Zurita and Nussbaum (2007) discussed the benefits of using mobile devices in the classroom to foster collaborative learning and have pinpointed that new opportunities exist to extend this to work outside the classroom.

In the last five years, our groups have been conducting research in two distinct but complementary research directions in line with the ideas described above. These efforts can be briefly described as follows: 1) the development of mobile and wireless applications and tools to support collaborative learning (Kurti et al., 2008; Vogel et al., 2010) and 2) the design and deployment of a web-based system to enable educators to create and reuse online collaborative scripts to support learning activities (Ronen et. al, 2006; Ronen & Kohen-Vacs, 2010). Our current research efforts focus on integrating these two approaches in order to explore how best to support the design and enactment of collaborative pedagogical scripts. Our envisioned learning activities include experiences across different learning contexts that are performed with stationary computers and mobile devices both in the classroom, in outdoors settings and at home. Our current contribution presents our efforts in this

direction. The paper is organized as follows; the next section briefly describes the CeLS (Collaborative e-Learning Structures) approach for designing and enacting online collaboration using scripts. The following section presents the potential of combining our two approaches and systems in order to offer teachers and CSCL researchers the ability to design and enact integrated pedagogical scripts that include collaborative activities in the classroom and in outdoors settings. One illustrative scenario is described and discussed in order to get a better understanding of the different aspects and outcomes that may result from the integration of our approaches. Finally, in the last section, concluding remarks are drawn and future steps are put forward.

Designing and Enacting Online Collaboration Scripts with CeLS

CeLS is a web-based system designed to enable teachers to design, enact, share and reuse structured online collaboration scripts and to incorporate them in existing instructional settings (Ronen et. al, 2006; Ronen & Kohen-Vacs, 2010). One of the salient features in CeLS is its ability to control the data flow in order to reuse learners' inputs and products from previous stages and to relate actions on these products to different social requirements. A script designed using CeLS may include any number of stages. A stage is comprised of a combination of basic building blocks, while each building block generates a certain type of interface in the student's environment. There are five types of building blocks that can be used to create a script that can include presentation, input, interaction, communication and operational objects.

Each object has particular properties that can be adjusted by the author (teacher) in order to adapt the resulting interface and its function to the specific needs of the activity. Some properties are generic, for instance, if the completion of a task is mandatory or not, and others are particular to the object or to its type, for instance, maximum and minimum text length and imposing the use of a certain vocabulary for a Text Input object. While using CeLS, social aspects are the key for controlling the data flow within a script. Each building block can be assigned with particular *Social Settings* that determine what information should be presented or which artifacts would be offered for interaction to each participant. The *Social Settings* may use pre-defined *Social Structures* that represent the characteristics of students' grouping. Since the functionality of a script is determined by attributing social properties to the script's building blocks, different participants may encounter different information, perform actions on different data items, or perform different actions, during the same activity stage.

CeLS enables the design and enactment of a large variety of online collaborative activities representing various pedagogical approaches such as: creating content, collaborative problem solving, responding to questionnaires, peer product assessment, competition, jigsaw, and any combinations of the above. The CeLS approach and its student interfaces were originally designed for being used with stationary and laptops computer connected to the World Wide Web only. Even if some of the scenarios implemented with the system involved outdoor activities (such as taking pictures at outdoor locations and submitting them to a competition activity), these aspects were not supported in ways that could take fully advantage of the potential offered by existing mobile technologies.

Towards an Integrated Approach for Scripting Mobile CSCL

Our current effort focuses on integrating the different approaches and features of CeLS and the Mobile Collaborative Learning System (MoCoLeS) (Vogel et al., 2010) in order to offer teachers and CSCL researchers the ability to design and enact integrated pedagogical scripts that include classroom and outdoor activities supported by mobile technologies. The table below illustrates our approaches, their potential, affordances and limitations.

Table 1: An overview of the MoCoLes and CeLS approaches.

Approach	CeLS	MoCoLeS
Potential & Affordances	Enables design, enactment, sharing and reusing of rich multi-stage web-based collaboration scripts.	Enables implementation of rich collaboration scripts enacted via mobile devices.
Limitations	Does not provide the functionality to deliver collaborative scripts to mobile devices.	Does not enable teachers authoring the script and it is specifically adapted for implementation with mobile devices.
Goal	Integrate our two approaches in order to explore how best to support the design and enactment of collaborative pedagogical scripts across different learning contexts. Learning activities are performed with stationary computers and mobile devices	

Integrating CeLS' capabilities with some of the features of MoCoLeS provide educators with the ability to design scripts to support collaborative activities that could be fully or partially enacted in outdoor settings using mobile devices. The integration of our approaches faces some issues related to interoperability

and exchange of data between these two environments. The creation of a CeLS script should be readable and executable by the mobile environment and the data and contributions provided by the mobile device should be processed in a way that makes sense when uploading them to the CeLS script representation. Since the CeLS system relies upon pre-defined types of building blocks, the incorporation of *mobile components* in the scripts poses additional challenges:

- Addition of new *Input building blocks* should be relevant and applicable only to inputs from mobile devices, such as positioning data.
- Adaptations of existing *Input building blocks* that would allow processing of data generated via mobile phone communication (cradle data sync, SMS, MMS or internet connection).
- Adaptation of relevant *Presentation and Interaction objects* to small scale displays that are typically used in mobile devices.
- Adaptation of the *Authoring interface*: define building blocks activated via mobile devices.

We have recently completed the initial integration phase of our systems, assuring interoperability between the two environments as illustrated in Figure 1.

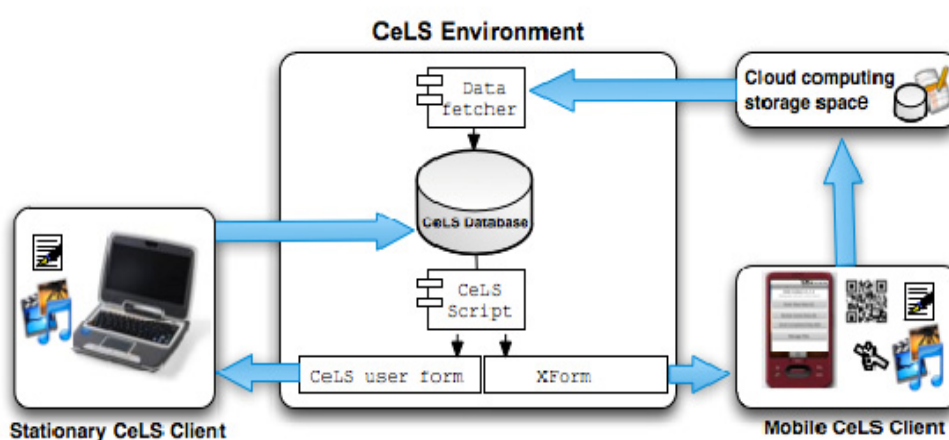


Figure 1. Integrating Mobile Activities in Cels Scripts.

The CeLS environment is used to define the script that consists of collaborative learning activities that include tasks that are supported by the stationary and mobile CeLS clients. The XForm component and the Open Data Kit (Anokwa et al., 2009) are responsible for generating the mobile phases of the learning activity based on the CeLS script. It should be noticed that this mobile script is presented in a way that complies with the format required for small displays. The content generated by the students using the mobile CeLS client (images, sounds or video objects, answers to questions and so on) can be stored locally in the mobile device or alternatively in a cloud computing storage space (in this particular case we are using Google Fusion Tables). The Data fetcher (as described in figure 1) is a software component responsible for retrieving the data from the cloud computing storage space and transferring it to the CeLS database.

Students can participate in a learning activity using computers or mobile devices, according to the type of task defined for each specific stage. The integration process described above ensures a continuous data flow within the script that enables to take full advantage of both mobile and 'stationary' elements: the contributions produced outdoors serve as reference inputs for further analysis and online discussion performed via large displays that enable complex and rich representations. Currently, we are about to deploy a number of learning activities in which these kind of integrated scripts will be tested by students. These scripts typically include at least one phase that is performed outdoors, individually or collaboratively, while the other parts of the activity could be performed online (using stationary computers) or face to face in the classroom. In the following section we described one specific scenario that illustrates our envisioned activities.

Scenario: Our Village

This activity is designed having in mind 5th grade students and it is part of the school curriculum. The objective of the activity is to allow students to gain knowledge about their own village and to learn about its history and important sites. The activity is performed by teams of students from the same class, from different classes in the same school or even with students from different schools. The script is described in Figure 2. All stages start with an introduction (A). The first stage consists of grouping students and assigning "messengers" groups to

various locations (G). The grouping can be automatic generated, or controlled by the students. In the second stage each group arrives to the assigned site, collects and submits information about the site (pictures, GPS location and queries about the site) using a mobile device (B).

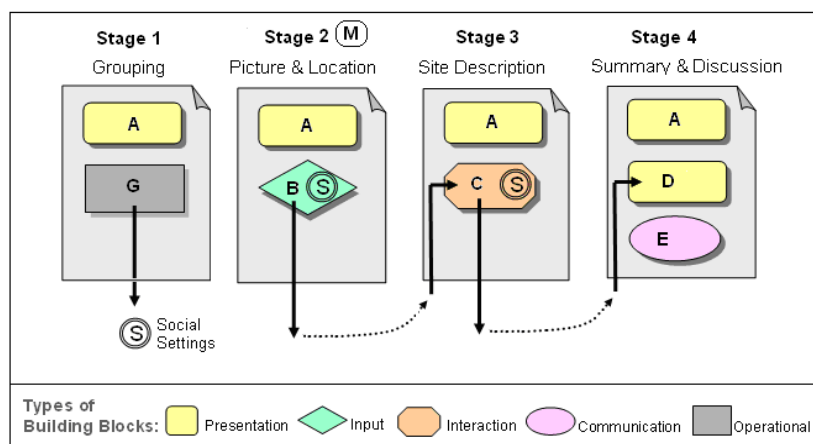


Figure 2. The Script of Our Village Activity. M – Mobile Stage.

At stage 3, groups become "explorers" and the sites are switched: each group is presented with the "messengers'" information and queries about a site (C). Group members need to explore the site attempting to provide answers to the messengers' queries using various resources such as web sites, books, interviewing relevant people or family members. This stage is performed as homework. Stage 3 can be followed by an online negotiation between the "messengers" and the "explorers" until all queries are answered. "Messengers" can now present new questions. The last stage consists of a presentation of the compound results produced by the learning community in various formats (table, photo album, digital maps) and a summary and discussion on the activity. This illustrative scenario has been conceived in order to take advantage of the features resulting from the integration of our systems. In this example, we have defined various learning tasks/activities (including artifact creation and submission, visualization and categorization, site description and discussion and summarizing) that required different types of technological support. Integrating different features of our two systems generates new opportunities to augment classroom activities enhanced by mobile technologies. These features enabled cross-context collaboration between groups of students in outdoors and indoors settings.

The flow and the logic of these activities have been supported by the technical functionalities of our integrated systems, as described earlier in figure 1. The mobile client of the MoCoLeS system provides the outdoor groups with the support required for completing their activities (i.e. artifact/content creation). These results are aggregated into a single presentation view provided by the CeLS system. Users using the web client of the CeLS system are able to perform additional collaborative activities (such as voting and categorization of content) about the artifacts created in the outdoor activities. The description of this scenario provide some initial indications illustrating the potential benefits of our integrated approach, namely the possibility of blending the functionalities of both systems in order to create additional support for cross-context collaborative learning activities. Integrating scripting and aggregating the capabilities of the CeLS system with the mobility support provided by MoCoLeS provides new opportunities for the design and deployment of collaborative learning activities.

Concluding Remarks and Future Efforts

In describing our current research efforts, we have illustrated one seamless learning scenario that augments classroom activities with information exchanges including geo-tagged mobile content. This scenario demonstrates how the combination of mobile and fixed technologies can sometimes support different aspects of the learning experience. More importantly, it demonstrates how this blend of technologies and educational approaches can support the design of learning experiences that go beyond the classroom settings and interweave with the learner's everyday life and into her web of personal knowledge, interests and learning needs.

The ideas and the scenario described in this paper demonstrate that students will need to deal with several learning devices and digital media, as well as different modes of interaction in order to complete a learning task. In order to achieve their learning goal, students may need to go through both collaborative and cognitive processes that are slightly different from those performed without such many artifacts. Our coming efforts include the implementation of the scenario described in this paper in order to understand the kind of classroom dynamics that can emerge based on these activities. We expect to collect enough empirical data in order to validate the potential benefits of our approach that can be characterized by the continuity of the

collaborative learning experience across different contexts. The results of these studies may suggest some initial pedagogical guidelines and ideas about how to orchestrate collaborative learning and scripts across contexts using stationary computers and mobile devices. Such type of investigations may help us to re-think the principle of “Less is More” (Buxton, 2001) and to reflect upon what is really helpful or harmful in these learning environments.

References

- Anokwa, Y., Hartung, C., Brunette, W., Borriello, G, Lerer, A. (2009). Open Source Data Collection in the Developing World. *Computer* 42, pp. 97-99.
- Buxton, W. (2001). Less is More (More or Less). In P. Denning (Ed.), *The Invisible Future: The Seamless Integration of Technology in Everyday Life*, New York: McGraw Hill, pp. 145-179.
- Chan, T.-W., Roschelle, J., His, S., Kinshuk, Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R., Norris, C., Soloway, E., Balacheff, N., Scardamalia, M., Dillenbourg, P., Looi, C. K., Milrad, M., & Hoppe, U. (2006). One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning*, 1(1), pp. 3-29.
- Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning: From design to orchestration. In N. Balacheff, S. Ludvigsen, T. Jong, A. Lazonder and S. Barnes, (Eds.), *Technology-Enhanced Learning: Principles and Products*, Springer Netherlands, Dordrecht, pp. 3-19.
- Dillenbourg, P., & Jermann, P. (2010). Technology for Classroom Orchestration. In M. S. Khine and I. M. Saleh, (Eds), *New Science of Learning*, Springer Science+Business Media, New York, pp 525-552.
- Hsi, S. (2003). A study of user experiences mediated by nomadic web content in a museum. *Journal of Computer Assisted Learning*, 19(3), pp. 308–319.
- Dillon, J., Rickinson, M., Teamey, K., Morris, M., Young, M., Sanders D., & Benefield, P. (2006). The Value of Outdoor Learning: Evidence of Research in the UK and Elsewhere. *School Science Review*, 87 (320), pp. 106-111.
- Kurti, A., Spikol, D., & Milrad, M. (2008). Bridging Outdoors and Indoors Educational Activities in Schools with the Support of Mobile and Positioning Technologies. *International Journal of Mobile Learning and Organization*, Volume 2 (2), pp. 166-186.
- Liu, C. C., & Kao, L. C. (2007). Do handheld devices facilitate face-to-face collaboration? Handheld devices with large shared display groupware to facilitate group interactions. *Journal of Computer Assisted Learning*, 23(4), pp. 285-299.
- Ronen, M., Kohen-Vacs, D. & Raz-Fogel, N. (2006). Adopt & Adapt: Structuring, Sharing and Reusing Asynchronous Collaborative Pedagogy. In Barab, S., Hay, K., & Hickey., D. (Eds), *Proceedings of the 7th International Conference on Learning Sciences*, pp. 599-606.
- Ronen, M. & Kohen-Vacs, D. (2010). Modeling, enacting sharing and reusing online collaborative pedagogy with CeLS. In: Persico, D. & Pozzi, F. (Eds.), *Techniques for Fostering Collaboration in Online Learning Communities: Theoretical and Practical Perspectives*, IGI Global.
- Vavoula, G., Sharples, M., Rudman, P., Meek, J., & Lonsdale, P. (2009). Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. *Computers and Education*, 53(2), pp. 286-299.
- Vogel, B., Kurti, A., Spikol, D, & Milrad, M. (2010). Exploring the benefits of open standard initiatives for supporting inquiry-based science learning. *Proceedings of the Fifth European Conference on Technology Enhanced Learning, EC-TEL 2010*, held in Barcelona, Spain, September 28-October 1, 2010, Lecture Notes in Computer Science, Springer-Verlag, Berlin/Heidelberg, pp. 596-601.
- Vogel, B., Spikol, D., Kurti, A, & Milrad, M. (2010). Integrating Mobile, Web and Sensory Technologies to Support Inquiry-Based Science Learning. *Proceedings of the 6th IEEE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education WMUTE 2010* held in Kaohsiung, Taiwan, April 12-16th, 2010, pp. 65-72.
- Zurita, G. and Nussbaum, M. (2007). A conceptual framework based on activity theory for mobile CSCL. In *British Journal of Educational Technology*, 38, 2, pp. 211-235.

The Design and Investigation of a Web-based Synchronous and Asynchronous Peer Feedback Mechanism

Eleni A. Kyza, Georgia Michael, Department of Communication and Internet Studies, Cyprus University of Technology, Cyprus

Email: Eleni.Kyza@cut.ac.cy, georgia3m@gmail.com

Costas P. Constantinou, Learning in Science Group, Department of Educational Sciences, University of Cyprus, c.p.constantinou@ucy.ac.cy

Abstract: Peer feedback has received increased attention as a mechanism for promoting learning. Our experiences with peer feedback indicate that students face challenges in providing and utilizing peer feedback. We report on the design and empirical investigation of a web-based tool with the intent to support students' collaborative inquiry by helping contextualize students' feedback. The effectiveness of the tool was tested with two classes of 6th grade students (n=39) at an elementary school in Cyprus. Students worked in small groups to solve a topical, socio-scientific problem. Each group in one class was paired with a group in the other class and was asked to peer review each other's work in progress on two occasions. Several types of data relating to the peer review processes were collected and analyzed qualitatively. Findings suggest that synchronous and asynchronous web-based tools can serve different roles in supporting peer feedback. Implications for design are discussed.

Introduction

Peer interactions can be powerful motivators for learning, as they provide opportunities for peers to exchange and critique ideas, allow for productive cognitive conflict, during which peers can either argue, negotiate meanings, or even restructure their own understanding, and can enhance social interaction, leading to a collaborative development of ideas (Damon, 1984; Hartup, 2008). Students' reactions to peer feedback are distinct from students' reactions to adults (such as teachers) questioning their ideas (Cole, 1991); in the latter case children most often succumb to the adult view, because of the asymmetrical nature of the adult-child relationship, in terms of the commonly accepted knowledge that each one holds, and also because of the power relations in the teacher-student relationship. Students may perceive peer feedback as less threatening and more understandable, than feedback provided by adults (Damon, 1984). Under certain conditions, peer feedback appears to be an effective mechanism for helping students learn (Kollar & Fischer, 2010; Phielix, Prins, & Kirschner, 2010; van Zundert, Sluijsmans, & van Merriënboer, 2010), even at the elementary school level (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). Most often, the arguments put forth in support of peer feedback processes are cognitive; however, researchers have also stressed the importance of the peer as a motivating factor and of social interaction in achieving better learning, pointing out that the socio-emotional aspect of collaboration can impact on the quality of the collaborative processes (Kreijns, Kirschner, & Jochems, 2003).

Peer feedback can be defined as the process of reviewing the work of an individual or of a group of students, with the goal of providing comments that can help peer(s) identify strengths and shortcomings, and help plan their future learning activities. Peer feedback is not about providing a grade or a score of achievement, nor does it concern feedback provided once a task is completed, unless the task is connected with another ongoing activity. Thus, we distinguish peer feedback from peer assessment, the latter focusing on a summative evaluation of students' work. As a construct, peer assessment has received more attention in the literature and has sometimes been used to include peer assessment both as learning and evaluative tool (van Zundert, Sluijsmans, & van Merriënboer, 2010). Most of these studies focused on higher education with little work conducted in secondary or primary settings –yet our experiences with students, as young as 6th grade, indicate that younger students are also able to participate in peer feedback sessions, but require guidance. Most work on peer feedback in CSCL situations involves providing peer feedback within a group. Phielix et al. (2010) investigated technology-based methods for supporting individual awareness of high school students' within-the-group behavior, seeking to enhance the group's social interaction, metacognition, and productivity. In contrast, this work explores a web-based tool for providing peer feedback between-groups of 6th grade students, as a mechanism for helping students look at their work critically. In this paper, we report on an exploratory, qualitative study, examining students' collaborative use of synchronous and asynchronous tools to provide peer feedback using a web-based mechanism during inquiry-based science learning.

Methodology

Participants

Two intact 6th grade classes (n1=20, n2=19), working in pairs or triads (7 groups in each class), from a public school in Cyprus participated in this study. Students had not participated in any extended inquiry-based project in the past. During the peer review phases, a group from one class collaborated with a group from the second class. The researchers decided how to pair up students in each phase according to the objectives of the task. For example, since the first peer review aimed at engaging students in discussing the subjective nature of scientific claims, groups with opposing claims were paired up; on the other hand, groups arguing in favor of the same opinion collaborated during the second peer review session to help each other improve their final claims. Two teachers participated in the classroom implementation. The first teacher had three years of teaching experience while the second teacher (the second author of this paper) had no in-service experience.

Data Collection and Analysis

Several forms of data were collected. Six groups' interactions (three from each class) with the learning environment, their peers and with their teachers were videotaped during the whole enactment. In addition, the synchronized computer logs of the feedback provided by all 7 pairs of groups using the WorkSpace sharing, logs of their chat exchange history, as well as the groups' work on the computer were collected. The data were analyzed using the activity theory framework (Engestrom, Miettinen, & Punamaki, 1999). In this paper, we use all groups' written work and the videotaped interactions of one group of three boys (Group 1 consisting of Mark, Anthony and Peter). During the analysis, all episodes involving Group 1 were identified and labelled according to the phase of peer review activity: 1) Preparing for peer review, 2) Selecting WorkSpace pages to share, 3) Peer Reviewing process, and 4) Examining and acting upon feedback received. The videos were transcribed verbatim from Greek and transcripts were coded for metacognitive comments (planning, monitoring, evaluating inquiry work). All comments provided in the groups' pages were analyzed in order to create a typology of students' comments while assessing the content of their peers' page. A similar analysis was performed with the chat log exchanges between groups. All the chat logs from both peer review sessions were coded so as to identify the nature of discussions that took place. More specifically, we tried to identify 1) categories of criteria students used to assess the content of their peers' page, 2) other issues they were concerned with, and, 3) whether they used design features such as the sentence openers.

Instructional Context

The learning environment "Meles-Meles", which was used in this study, was hosted on the STOCHASMOS (Kyza & Constantinou, 2007) web-based platform. The context of the investigation was a socio-scientific issue on the bovine tuberculosis problem in cattle in the U.K. Each group of students assumed the role of scientists who represented relevant organizations, charged with the goal of studying the data and constructing evidence-based scientific claims on how the problem could be best solved. The implementation lasted for 10 weeks (24 40-minute sessions) and was kept similar in the two classrooms in relation to the duration, the activity sequence and the teachers. The activity sequence included two peer review sessions (PRS1 and PRS2). The first session lasted for three 40-minute periods, whereas the second session lasted one 40-minute lesson, including the time needed for providing task-related instructions. The activity sequence provided students with multiple opportunities to construct and evaluate scientific claims and it systematically engaged them in explicit reflective discourse on the subjective and uncertain nature of scientific claims (Khishfe & Abd-El Khalick, 2002). Firstly, students were introduced to the problem and were assigned the role of scientists who need to construct scientific claims as to whether badgers should be culled. This led to the development of an operational definition for scientific claims through the use of specific WorkSpace templates on the STOCHASMOS platform. Then students were expected to study the available data and construct their own scientific claims. After students had constructed at least two claims, they were asked to evaluate the scientific merit of another group's claim. This was the *first peer review session* which served as an opportunity for students to apply specific criteria. Feedback was given between groups with different roles and this led to discussions about the subjectivity of data. Next, students were given time to improve their claims based on their paired group's comments. Then, in a whole class discussion, two claims were compared in order to choose the most convincing one. Since all claims were scientific, evaluating only the scientific merit of the claims was not enough, leading to the development of criteria for evaluating the validity and reliability of scientific claims. This activity was accompanied by discussions on the role of emerging evidence in determining the trustworthiness of a claim (e.g., the accumulation of supporting evidence enhances its reliability while the emergence of conflicting evidence puts its validity into question). Following this activity, the second peer review session took place. Feedback between groups with the same roles was given in order to help each other get prepared for the final conference and, thus, have an opportunity to apply all criteria. Finally, a conference took place where groups of students presented their claims and evaluated other groups' claims.

Synchronous and Asynchronous Peer Feedback Tools

The activity sequence included two peer reviewing sessions using the STOCHASMOS collaboration tools. STOCHASMOS is a web-based platform designed to host problem-based investigations and to scaffold students' collaborative reflective inquiry. The learning environments developed using this platform consist of the *Inquiry Environment*, where the scenario of the investigation is described and the relevant data are presented, and the reflective *WorkSpaces*. The Inquiry Environment represents data to students using multi-modal formats, such as text, graphs, pictures and videos. The *data capture tool* enables students to automatically record data as evidence. The selected data are automatically transferred to the *WorkSpace*, where students can organize and interpret them using *templates* designed for each learning environment. Each template contains teacher-designed prompts for scaffolding students' reflective inquiry.

The platform also consists of tools supporting synchronous and asynchronous communication between groups of students. The *Workspace Sharing area* was designed to scaffold the asynchronous feedback provided between peers in relation to their work in the WorkSpace. The WorkSpace Sharing area offers students the opportunity to collaborate with other groups in their classroom or in other schools, by allowing them to select and share their WorkSpace pages (e.g. data pages, explanation pages) in order to receive and provide peer feedback. Each group can identify the WorkSpace pages they would like to share with their collaborating group, and can activate or de-activate sharing as they wish. They can view the collaborating group's review of their work by visiting the WorkSpace sharing tab of STOCHASMOS. Students can also access a log of previously saved peer comments. Figure 1 shows the WorkSpace Page Sharing tool. Workspace Sharing provides students with tools to facilitate the review process, such as the ability to add comments to their peers' data pages. The comments are added in the form of annotation notes. Students' work is saved as a new version of the original page, while the original page is maintained. This gives students the opportunity to continue their work and selectively apply the changes proposed by their peers. Groups who share a WorkSpace page can access the original page as well as the page with the comments from the group's WorkSpace. When a group adds comments to a page, the other group is automatically notified. Selecting the corresponding icon, students can view their partner's group comments. The between-groups collaboration tools build upon students' work with the WorkSpace templates.

Another collaboration tool in STOCHASMOS is the *chat tool* (Figure 1) which can be used for synchronous communication between two paired groups in order to support the process of seeking and providing comments and clarifications. This tool appears as a separate, movable window above the main platform in order to give students the possibility to have visual contact with the Inquiry Environment or WorkSpace pages. Designers of learning environments can add prompts in the form of customizable sentence starters or questions in order to help students focus on the objectives of the communication but without eliminating their autonomy. When a group sends a message to their partner group, the other group is automatically notified. The same happens when the teachers, who can remotely monitor and participate in students' discourse, send an instant message for facilitating students' discourse.

The screenshot displays the STOCHASMOS interface within a Windows Internet Explorer browser. The main workspace contains a graph with two data series (blue and red) and a text box with a comment: "But you totally ignored years 1951-1998. These data are not consistent with what you suggest." Below the graph is a table of data points. A chat tool window is open, showing a list of sentence starters such as "The data you use are scientific because..." and "Your claim is not scientific because...". Annotations with arrows point to the chat tool, the sentence starters, the comment, and the graph area.

Figure 1. The STOCHASMOS Collaboration Tools.

Findings

We report on findings relating to the nature of the web-based asynchronous and synchronous peer feedback by examining the annotations provided by each group using the WorkSpace Page Sharing tool, the comments exchanged via the chat tool, and the videos of Group 1 discourse and interaction during the Peer Review sessions. Based on the Activity Theory framework (Engestrom, et al., 1999), three different states of activities were identified, all situated within the community of the classroom: (a) page sharing and students' written peer-review comments, (b) students' discourse and activity around these comments, and (c) intergroup communication using the chat tool. The examination of the groups' asynchronous peer review comments indicated that the paired groups reviewed a total of 34 WorkSpace pages during PRS1 and 13 pages during PRS2. A content analysis of the feedback indicated that most of the comments during both peer review sessions ($n_1=21$, 67%, $n_2=8$, 61%) were relevant to the task and related to the content of the pages. Some comments concentrated on whether their partners responded to all the questions of the template ($n_1=7$, 23%, $n_2=4$, 31%). The analysis of the feedback provided by the groups indicated that the written feedback, even though brief, was contextualized, specific and relevant to the peer review task students were asked to perform, with only three comments during PRS1 (10%) and one (8%) during PRS2 not directly relevant to the task. In addition, the comments provided addressed issues which were not explicitly setup by the task, focusing on the reviewed group's interpretations, indicating agreement, or disagreement, and asking for more complete articulations of students' interpretations. An analysis of the chat conversations indicated that students used the chat tool mostly for phatic communication and for coordinating the sharing of data in the WorkSpace Sharing space. Whenever students argued about claims in the chat tool, these discussions lacked the contextualization and the support of data. The analysis of the videotaped discourse of Group 1 during the peer review sessions illustrated the relationship and timing between each of the activities (page sharing, providing comments, chatting) and mapped the interdependencies between offline and online activities. This analysis provided evidence that the page sharing activity engaged students in reflective practices, such as monitoring their process, evaluating their work and proposing a course of action prior to sharing their pages.

Specifying the time periods in which the peer review should take place influenced the within-the-group discourse, as students were primarily concerned with making contact with the other group and receiving comments. Group 1 students were facile with using the collaboration tools but technical, network-related problems and the task setup delayed the process of exchanging comments. Technical difficulties, which were related to the school's network infrastructure, also influenced the nature of the student conversations and their interactions with the teacher, placing emphasis on procedural and logistical issues. As shown in Table 1, this behavior, however, did not preclude students from giving relevant, written comments, even though a different task setup might have improved the peer review process.

Based on the analysis of the discourse of Group 1 and the analysis of all chat logs, students were eager to receive their peers' feedback, something that strengthens the belief that peer feedback may increase students' motivation to engage with the task. The analysis of the interactions between peers and the software tools also indicated that socio-technical and task structuring decisions delayed the process of providing feedback and limited the time devoted to discussions. This analysis suggested that a more efficient activity structure could address socio-technical and task structuring problems in future enactments. Finally, the teacher also played a role in coordinating the activity, by regularly visiting the groups and monitoring their work.

Discussion and Implications

This exploratory study contributes to knowledge about peer feedback processes in collaborative, inquiry based learning in elementary school, a topic currently understudied. The study explored the role of synchronous and asynchronous representational web-based tools in providing and receiving peer feedback. Findings indicate that a) collaborative peer feedback is feasible even at the elementary school level, and b) asynchronous and synchronous representational and communication tools can support different aspects of the peer feedback process. The data presented support a broader function of the communication tools than the one originally intended. For instance, students did not adhere only to the task of employing epistemological criteria to asynchronously assess the other group's claims but spontaneously engaged in exchanges which were desirable but not explicitly requested by their teacher. Such observations indicate that the students appropriated the tool and that such peer review sessions can serve for providing peer feedback on varied aspects of the students' work. We believe that the visual representations of students' work contextualized and helped focus the WorkSpace sharing comments on task-related issues.

The findings of this study have implications for the re-design of the collaborative, peer feedback tools and the context within which they can be used. For example, we found that most of the chat exchanges were consumed by socio-emotional and procedural interactions. It appears that the use of group names, instead of the students' real names in the chat tool, was an obstacle to focusing the communication on the cognitive task, as each group wanted to identify which school mates participating in their paired group. We hypothesize that this type of phatic communication will continue to exist even in the cases when student groups do not attend the

same school. Possible design modifications to address this could be to explore ways in which paired groups can become acquainted through other means (e.g. initial video conference sessions, development and exchange of WorkSpace profile pages, visual cues embedded in the chat tool). It is also possible that the observed behavior may be due to the novelty of this type of computer-mediated interaction between the students and that this behavior may change in future similar experiences. Furthermore, it maybe that this type of synchronous communication serves the need for socio-emotional communication, as identified by researchers (Kreijns, Kirschner, & Jochems, 2003) chat exchanges may played a complimentary role to the more cognitively-oriented processes supported by the WorkSpace sharing space. Findings about a differentiated role of software tools to support collaborative learning have been suggested elsewhere in the literature (Stahl, 2009). Our own findings provided us with context into how these tools work in early years' science education peer feedback sessions. Findings also indicate that the groups did not use the scaffolding represented in the chat tool in the form of sentence starters or questions. This maybe a usability or a cognitive support issue that should be explored in future studies.

A second design implication concerns the task activity structures, involving the use of the collaborative peer review tools. By design, the Peer Review Sessions were constrained in two sessions, instead of freely allowing groups to exchange comments at any point during their investigation, to avoid an excessive amount of non-task focused communication and to respond to time constraints imposed by the school schedule. Our findings have led us to reconsider this task setup, as it precluded us from observing students' spontaneous patterns of interaction during such sessions. Future studies will address this issue and other limitations of the present study, such as the need for gaining more insight about the tools and feedback processes through extended interviews of the students using the tools, and analyzing the discourse and interaction for a larger number groups.

References

- Cole, D. A. (1991). Change in Self-Perceived Competence as a Function of Peer and Teacher Evaluation. *Developmental Psychology*, 27(4), 682-688.
- Damon, W. (1984). Peer education: The untapped potential. *Journal of Applied Developmental Psychology*, 5(4), 331-343. doi: Doi: 10.1016/0193-3973(84)90006-6
- Engestrom, Y., Miettinen, R., & Punamaki, R. L. (Eds.). (1999). *Perspectives on Activity Theory*. Cambridge.: Cambridge University Press.
- Hartup, W. D. (2008). Critical Issues and Theoretical Viewpoints. In K. H. Rubin, W. M. Bukowski & B. P. Laursen (Eds.), *Handbook of Peer Interactions, Relationships, and Groups* (pp. 3-): The Guilford Press.
- Khishfe, R., & Abd-El Khalick , F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented Instruction on sixth graders' views of nature of science. *Journal of Research in Science teaching*, 39(7), 551-578.
- Kollar, I., & Fischer, F. (2010). Peer assessment as collaborative learning: A cognitive perspective. *Learning and Instruction*, 20(4), 344-348. doi: DOI: 10.1016/j.learninstruc.2009.08.005
- Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior*, 19(3), 335-353. doi: Doi: 10.1016/s0747-5632(02)00057-2
- Kyza, E. A., & Constantinou, C. P. (2007). *STOCHASMOS: a web-based platform for reflective, inquiry-based teaching and learning* [software, <http://www.stochasmos.org>]. Cyprus: Learning in Science Group.
- Phielix, C., Prins, F. J., & Kirschner, P. A. (2010). Awareness of group performance in a CSCL-environment: Effects of peer feedback and reflection. *Computers in Human Behavior*, 26(2), 151-161. doi: DOI: 10.1016/j.chb.2009.10.011
- Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003). Peer-Assisted Learning Interventions With Elementary School Students: A Meta-Analytic Review. *Journal of Educational Psychology*, 95(2), 240-257.
- Stahl, G. (2009). Designing a Mix of Synchronous and Asynchronous Media for VMT. In G. Stahl (Ed.), *Studying Virtual Math Teams* (Vol. 11, pp. 295-310). New York: Springer US.
- van Zundert, M., Sluijsmans, D., & van Merriënboer, J. (2010). Effective peer assessment processes: Research findings and future directions. *Learning and Instruction*, 20(4), 270-279. doi: DOI: 10.1016/j.learninstruc.2009.08.004

Acknowledgments

This study was funded by the Cyprus Research Foundation (PLIRO/0506/21). Any opinions, findings, and conclusions expressed in this study are those of the authors and do not necessarily reflect the views of the Cyprus Research Foundation.

An Execution Semantics to Support Flexibility in Collaborative Learning Scripts

Roberto Pérez-Rodríguez, Manuel Caeiro-Rodríguez, University of Vigo, Spain
Email: rperez@gist.det.uvigo.es, Manuel.Caeiro@det.uvigo.es

Abstract: Flexibility is a key concern on the adoption of model-based solutions to computationally support collaborative learning. These solutions address the structuring of collaborative activities in pre-specified ways, maximizing the chance of occurrence for certain desirable interactions. Nevertheless, it is very difficult, if not impossible, to be able to predict the unfoldment of collaborative learning activities. Therefore, a flexible solution that allows changes during the run-time is a basic requirement. This paper presents a solution to this problem by following an object-oriented modelling approach. It also involves an execution semantics based on hierarchical finite state machines networks. Together, these two approaches enable to manage the enactment of collaborative learning models and to perform changes in a non-disruptive way. The paper uses a typical JIGSAW activity to illustrate the need for this kind of solution.

Introduction

Model-based solutions have been widely discussed in the field of Computer Supported Collaborative Learning (CSCL). There have been several model-based initiatives with different names, mainly CSCL scripts (Dillenbourg, 2002; Dillenbourg & Hong, 2008), but also Educational Modelling Languages (Rawlings et al. 2002) or Visual Instructional Design Languages (Botturi & Stubbs, 2007; Caeiro-Rodríguez et al., 2010), such as the IMS Learning Design (IMS LD) specification (IMS, 2003). The key idea underlying these initiatives is to provide a computational modelling language that enables the description of collaborative learning plans. Later, such descriptions can be processed by appropriate computer applications in order to enact the corresponding collaborative learning experiences. In this way, the application can arrange a particular and precise learning environment for each user (eg. learner, teacher) and activity. A variety of issues can be managed in order to structure the learning plan (Kollar et al., 2006), such as the activities that should be carried out by each participant, how participants are sorted into groups, the order in which activities should/could be performed, the transfer of resources among activities, the environments in where each participant should work, etc. These functionalities facilitate the management and development of collaborative activities, providing support both for teachers and learners by triggering group interactions in certain desirable ways. Eventually, the way in which the computer application can support collaborative learning depends on the expressiveness of the computational modelling language. Nevertheless, nowadays expressiveness is not a main concern in these model-based solutions.

Flexibility has become the main concern towards the adoption of model-based solutions to support collaborative learning (Dillenbourg & Tchounikine, 2008). Some times authors have argued against the development of this kind of solutions because collaborative learning is highly unpredictable and it cannot be prescribed in a lesson plan (Dillenbourg, 2002). Many times, plans need to be modified and changed continuously during the enactment (run-time). A solution to this problem is adaptation (Ferraris et al. 2009; Specht & Burgos 2006), taking into account during the design-time the various alternatives or situations that can be produced later. In this way, some approaches support some kind of pre-defined adaptations that enable to capture the possible alternatives and the conditions to choose among them during run-time. More over, other solutions also include late-modelling constructs that enable to delay the modelling of certain parts to the future, after the learning process has already begun (Zarraonandia et al., 2006). These solutions provide some degree of flexibility to model-based solutions, but it is not enough. A complete solution should enable to perform any change to the learning plan at any time during its enactment, without bringing the system down.

This article shows a solution to support flexibility during the enactment of learning plans. This proposal is based on the adoption of an object-oriented modelling solution inspired on the workflow domain (Redding et al., 2010) instead the more typical task oriented approaches (as in IMS LD). Three of the key mechanisms involved in this proposal are: (i) the management of instances for each element involved in the enactment of the learning plan maintaining a particular state for each instance; (ii) the definition of an execution semantics based on event-condition-actions (ECA) rules that define the behaviour of the different elements and their relations; and (iii) the definition of an API that enables to monitor the state of the different instances, to make changes on the model or to force the state of certain instances. This solution enables to perform changes in the models without bringing the supporting application down (namely: hot changes).

Flexibility

The description of collaborative learning plans expressed as computational models involves a intrinsic dilemma (Dillenbourg & Tchounikine, 2008): “*if the scaffolding is too weak, it will not produce the expected interactions; if it is too strong, it will spoil the natural richness of collaboration*”. In addition, as argued in the previous introduction, it is really difficult if not impossible to predict and gather all possible alternatives in learning plans. The solution to this problem is flexibility, defined as the capacity of a computational application that enacts learning plans to change its behaviour in not previewed ways when requested by an authorized user (i.e., a teacher or a learner). In other words, learning plans prescribe certain behaviours for the supporting application in terms of several issues: assignment of activities to users; grouping of users; transfer of resources; composition of learning environments, etc. During the enactment learning plans may need to be changed and the system has to behave appropriately supporting such changes without requiring to re-start the system.

Let see a typical collaborative learning use case where flexibility is required. We consider a common collaborative scenario: the JIGSAW. JIGSAW is a well-known technique for collaborative learning (Aronson et al., 1978). Students typically use it in face-to-face settings without computer support (see <http://www.jigsaw.org>). The typical JIGSAW technique involves three stages as follows: (i) group formation and individual reading; (ii) expert groups; (iii) collaborative groups.

Several authors have developed computer applications supporting the management of JIGSAW learning activities (Gallardo et al., 2003). Moreover, a main issue in some of these developments has been the provision of adaptations and flexibility support (Pérez-Sanagustín et al., 2009). The support of the JIGSAW by a computer application demands three types of flexibility solutions:

- Type 1: **expected variations**. This is the basic typical requirement as identified in Pérez-Sanagustín et al. (2009). In the JIGSAW case we may have variations in relation with the total number of learners, the number of parts in which the lesson materials are divided, etc. In addition, we could consider if these variations can be produced just before the system begins to enact the JIGSAW (configuration time), or if they can be produced once the enactment has already begun. The first situation involves a typical adaptation problem, whereas the second demands a more flexible solution as it is required to change the execution state of the application.
- Type 2: **global variations**. These are changes that affect to the whole learning plan and therefore they have to be translated to all the instances during the enactment. For example, to include a new task between the first stage and second JIGSAW stages in order to clarify the general goal of the activity to all learners. This type of change affects to all the participants involved in the system. Similarly to the previous type, this change can be produced when no instance of the second stage has been initiated (which could be considered as an adaptation problem), or when some of those instances have already been launched. This last option is more complex as we need to revert the system to a previous stage, where learners cannot continue working in stage 2 until the new task is concluded.
- Type 3: **particular variations**. These are changes that affect to specific elements during the enactment. For example, if a learner drops-out some activities, they are not going to be concluded or some groups will not be able to work in the intended way. Therefore, the enactment system may need to change the state of some instances in order to continue supporting the overall learning process. These changes will affect just to particular instances and not to the whole enactment.

Following sections introduce our solution for supporting these three types of flexibility. It is mainly provided through the execution semantics of the supporting application. In addition, the execution semantics is built on top of PoEML, acronym of Perspective-oriented Educational Modelling Language (Caeiro-Rodríguez et al., 2007).

Execution Metamodel

PoEML follows a declarative (constraint-based) approach to the modelling of learning plans (van der Aalst et al., 2009). The declarative approach gives a great freedom degree in run-time, because the execution control of a lesson plan is modelled as a set of constraints, and the consistency of instances is guaranteed whenever the constraints are not broken. The execution metamodel describes the enactment of the computational PoEML models. In our case, this metamodel follows an object-oriented approach and it is developed in the following ways:

- The elements in the modelling language are *classes* and their instances are *objects*. PoEML includes elements used in the specifications and expressions that are also translated into *classes* and then *objects* in the execution model. These elements are used to establish relationships among the main PoEML elements.
- The set of possible execution states for an *object* is modelled as a Finite State Machine (FSM).
- A complete *execution model* is composed by a hierarchical network of interrelated Finite State Machines.

This hierarchical FSM approach facilitates the introduction of changes during enactment (Lee et al. 2002). In order to support the maximum degree of flexibility, the following has to be noted:

- A *declarative approach* is key to overcoming the so called *dynamic change bug*, that is, possible inconsistencies in the *model instance* migration process after a change (van der Aalst et al., 2009).
- Traceability between *designed (paper-based) models*, *computational (PoEML) models*, and *executing models* is key to supporting run-time changes. In other solutions there are irreversible translation from the *designed to computational* and to *executing models* that makes impossible to trace back the execution.

Another main issue in this metamodel is the instances creation process. Instance creation is produced in an on-demand approach. Each element instance is created when it is needed and this happens when its parent container (typically an ES) is accessed by an user. This is a very scalable solution that facilitates the performance of changes in those parts of the models that have not been instantiated yet (late modelling). In other way, instance deletion is not possible. Instead, *cancelled* and *orphan* states are identified to represent the deletion of a certain element. In this way it is facilitated the update of the related elements' FSM.

Formalisation

The execution metamodel is defined as three separated parts for the sake of clarity:

- The **situation part** defines the FSMs for all the *classes* in PoEML.
- The **execution part** defines how an event in one FSM changes the state of the FSM network in which it is contained.
- The **change part** defines how a change in the *model* changes its related *model instances* (FSM networks).

Situation Part

The **situation part** of a FSM network is a screenshot of the individual FSMs that it contains. Individual FSMs are designed in such a way that it allows on-demand re-evaluation, that is, the state of a particular *object* can be re-calculated whenever it may be needed, because it depends only on the value of its contained *properties*. As PoEML models consists of networks of related elements, changes are propagated through FSMs in an automated way.

Next figures show two of main FSMs of the PoEML execution metamodel: ES and Goal. In the top left part of these figures is compiled the set of properties of these classes. Changes in these classes determine the transition from one state to another. It is also represented the methods performed when each state is achieved. For example, in Figure 1 when an ES is cancelled its contained Goal instances have to be cancelled too.

Figure 1 shows the extended state-transition diagram for an ES. The possible states are:

- **Not created:** the ES has not been created yet.
- **Not accessible:** the ES has been created but participants cannot access to it yet. The possible reasons may be that other ESs have to be done beforehand, or that the ES is scheduled to be accessed at a particular time.
- **Accessible:** participants are able to access the ES.
- **Active:** at least a participant has accessed the ES.
- **Finished:** there are no remaining goals to be achieved in the ES.
- **Orphan:** the parent ES is cancelled or orphan.
- **Cancelled:** the ES has been cancelled by an authorised user.

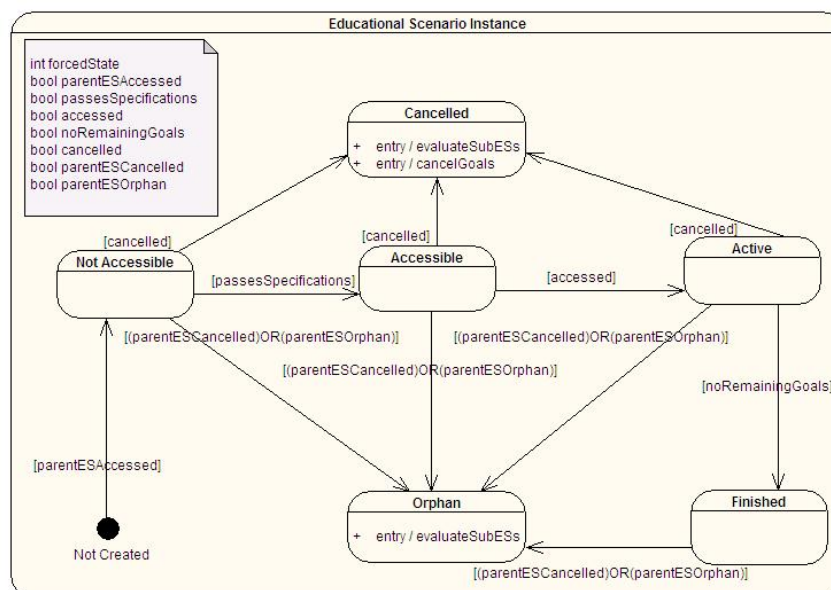


Figure 1. ES Instance Finite State Machine.

In a way similar to ESs, Goals have also an associated state-transition diagram. The possible states are:

- **Not created:** the Goal has not been created yet.
- **Not accessible:** the Goal has been created but participants cannot attempt it yet. The possible reasons may be that there are whether an unsatisfied input constraint or attempt dependency.
- **Attemptable:** participants are able to attempt the Goal.
- **Pending:** the Goal has been attempted, but its achievement has not been evaluated yet.
- **Failed:** participants have failed to achieve the Goal.
- **Achieved:** participants have succeeded to achieve the Goal.
- **Expired:** the temporal deadline has been reached.
- **Orphan:** the parent Goal is cancelled or orphan.
- **Cancelled:** the Goal has been cancelled by an authorised user.

Execution Part

The **execution part** deals with the strategy to propagate events in a FSM network. It clearly describes how a single update in the state of an *object* triggers changes up in the *model instance* into which it is contained, updating the state of related *objects*. The two key requirements are to support termination and confluence. Termination means that the chain of triggered events must not continue indefinitely. Confluence means that in for the same set of initial *situations* and triggered events, the final situation after two different executions must be the same one. These two requirements are supported as follows:

- The events flow is always an acyclic graph, guaranteeing that there are no loops, so termination is guaranteed
- Also, the events flow is hierarchical, and there are no concurrent events, so execution is always confluent.

Change Part

The **change part** deals with run-time changes in *models* and *model instances*. In particular, it manages:

- Changes in *models*: these are a set of primitives that enable to commit atomic changes on running *models*. Here, two strategies are considered:
 - To create a new version of the *model*. With this strategy, all future *model instances* will conform to a new version of the *model*, whilst old *model instances* will still be following an old version of the *model*. This approach is conservative, but it is useful in some use cases.
 - To update all *model instances*. With this strategy, all *model instances* are migrated to a new version of the *model*.
- Changes in *model instances*: these are a set of primitives that enable to commit atomic changes on running *model instances* without affecting other running *instances* from the same *model*.

On-the-fly reconfiguration is achieved automatically as all the changes trigger the re-evaluation of the states of all the related instances.

Architecture & Implementation

We have developed an implementation of an execution engine for PoEML courses that conforms to the execution model presented in this paper and that follows a typical three-layer design pattern. The *presentation layer* of the system has been developed in PHP and uses the NuSOAP library to consume the service methods of the execution engine. The execution engine forms the *business logic layer*. It has been implemented as a Web application running in Tomcat and we use the Axis framework for publishing the service methods. Table 1 gathers some of the methods provided by the execution engine. Finally, there is a *database layer* that maintains two separate schemas: one for PoEML models, and another one for run-time instances. These two models are not fully independent, because a change in one element of the model may trigger as many changes in the corresponding instances as instances are running in the execution engine. The Database Layer has been implemented in Oracle 11g.

Conclusions

CSSL is devoted to search for environments that directly or indirectly favour the emergence of rich and intensive interactions. Model-based approaches try to facilitate and promote the performance of certain desirable interactions by structuring the computational support provided by appropriate applications. Nevertheless, fixing such structuring and the corresponding degree of coercion is a delicate design choice (Dillenbourg & Tchounikine, 2008): “*too constrained environments would spoil the richness of collaborative interactions; too open environments would fail to induce the desired collaborative interactions*”. A solution to this problem is achieved by providing flexibility in supporting applications. The computer application should behave as specified in the modelled plan as long as it unfolds in the desirable way. Nevertheless, if some difficulty is detected or some unexpected concern appears, the system should allow to modify the initial plan and to continue

supporting the learning process without disrupting it. The solution presented is a step toward this based on an object-oriented modelling approach and on hierarchical finite state machines networks execution semantics.

Table 1: Sample of service methods in the execution engine interface. The ‘:’ means that it is retrieved an object, and [] means that it is retrieved an array.

Method	Input parameters	Output parameters	Description
<i>Information retrieval</i>			
getESInstancebyESId	id	:ESInstance[]	Retrieves all ES Instances from a ES
getEnvironmentInstancesByESInstanceId	ESInstanceId	:EnvironmentInstance[]	Retrieves all Environment Instances from a given ESInstance
<i>Authoring/changes</i>			
setESMultiplicity	id, multiplicity		Inserts the multiplicity of an ES
cancelGoalInstance	id		Cancels a Goal instance
updateDeadline	ESId, deadline		Changes a deadline

References

- Aronson, E., Blaney, N., Sikes, J., Stephan, G. & Snapp, M. (1978). *The jigsaw classroom*. CA: Sage.
- Botturi, L., Stubbs, T. (eds.) (2007). *Handbook of Visual Languages in Instructional Design: Theories and Practices*. Hershey, PA: Idea Group.
- Caeiro-Rodríguez, M., Marcelino, M. J., Llamas-Nistal, M., Anido-Rifón, L. & Mendes, A. J. (2007). Supporting the modelling of flexible educational units PoEML: a separation of concerns approach. *Journal of Universal Computer Sciences*, 13(7), 980-990.
- Caeiro-Rodríguez, M., Dertml, M. & Botturi, L. (2010). Special issue on visual instructional design languages. *Journal of Visual Languages and Computing*, 21(6), 311-312.
- Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen.
- Dillenbourg, P. & Tchounikine, P. (2007). Flexibility in macro-scripts for computer-supported collaborative learning. *Journal of Computer Assisted Learning*, 23(1), 1-13.
- Dillenbourg, P. & Hong, F. (2008). The mechanics of CSCL macro scripts in Computer-Supported Collaborative Learning 3:5-23.
- Ferraris, C., Vignollet, L., Martel, C., Harrer, A., & Dimitriadis, Y. (2009). Competitive challenge on adapting activities modeled by CSCL scripts. Workshop at the CSCL 2009. June 8, 2009, Rhodes, Greece.
- Gallardo, T., Guerrero, L. A., Collazos, C., Pino, J. A. & Ochoa, S. (2003). Supporting JIGSAW-type collaborative learning. Proceedings of the 36th Annual Hawaii International Conference on System IMS (2003). IMS Learning Design: Information Model, Best Practice Guide, Information Binding, XML examples and Schemas.
- Kollar, I., Fischer, F., & Hesse, F. (2006). Collaboration Scripts--A Conceptual Analysis. *Educational Psychology Review*, 18(2), 159-185.
- Lee, S., Yoo, S. & Choi, K. (2002). Reconfigurable SoC design with hierarchical FSM and synchronous data flow model. Proceedings of the tenth International Symposium on Hardware/Software Codesign.
- Pérez-Sanagustín, M., Burgos, J., Hernández-Leo, D., & Blat, J. (2009). Considering the intrinsic constraints for groups management of TAPPS & Jigsaw CLFPs. Proceedings of International Conference on Intelligent Networking and Collaborative Systems (INCoS 2009). November, 2009, Barcelona, Spain.
- Rawlings, A., van Rosmalen, P., Koper, R., Rodríguez-Artacho, M. & Lefrere, P. (2002). *Report on Educational Modeling Languages*. CEN Workshop Agreement.
- Redding, G., Dumas, M., ter Hofstede, A. H. M. & Iordachescu, A. (2010). A Flexible, Object-centric Approach for Business Process Modelling. *Service Oriented Computing and Applications*, 4(3):191-201.
- Specht, M. & Burgos, D. (2006). Implementing adaptive educational methods with IMS Learning Design. Proceedings of Adaptive Hipermedia (AH 2006). June, 2006, Dublin, Ireland.
- van Der Aalst, W. M. P., Pesic, M., & Schonenberg, H. (2009). Declarative workflows: Balancing between flexibility and support. *Computer Science Research and Development*, 23(2), 99-113. Springer.
- Zarraonandia, T., Fernández, C., & Doderó, J. M. (2006). A Late Modelling Approach for the Definition of Computer-Supported Learning Process. Proceedings of Adaptive Hypermedia. (AH 2006). June, 2006, Dublin, Ireland.

Acknowledgments

We want to thank *Ministerio de Ciencia e Innovacion* for its support to this work under grant “Methodologies, Architectures and Standards for adaptive and accessible e-learning (Adapt2Learn)” (TIN2010-21735-C02-01).

PeerSpace: An Online Peer Collaborative Learning Environment for First Year Computer Science Students

Cen Li, Zhijiang Dong, Roland H. Untch, Nathan Reale, Michael Chasteen, Department of Computer Science, Middle Tennessee State University, Murfreesboro, TN 37132

Email: cli@mtsu.edu, zdong@mtsu.edu, untch@mtsu.edu, ncr2g@mtmail.mtsu.edu, mchasteen1@gmail.com

Abstract: Dropout and failure rates in introductory Computer Science (CS) courses are distressingly high. It has been observed that, success in CS courses improves when students form effective peer support networks. Unfortunately students are often unable to create such support networks on their own and educators have had few tools at their disposal to help promote the formation of such peer support networks. This paper discusses an integrated peer collaborative learning environment, called *PeerSpace*, developed to help educators help students form peer support networks, increase motivation, and ultimately improve learning. In addition to online learning tools developed for CS education, social components such as forums, blogs, wikis, groups, and chat, are integrated into *PeerSpace*. Comparative studies were conducted to measure the effectiveness of the system among students taking CS1 courses. Preliminary results from these studies suggest that *PeerSpace* was successful in building peer support networks and gave positive impact to learning outcomes.

Introduction

Among the factors dragging down success rates in CS courses, counterproductive student attitudes have been one of the most difficult for educators to effectively confront. Studies of students in introductory computer science (CS) courses reveal problems with: combativeness towards the opinions of peers, unwillingness to support or aid others, procrastination on assignments, disdain for working in groups, and a lack of motivation, persistence, and passion towards the course material (Kinnunen & Malmi, 2006; Waite & Leonardi, 2004). As a result, dropout and failure rates as high as fifty percent have been a common phenomenon in introductory CS courses (i.e., CS1 and CS2) nationwide (Kinnunen & Malmi, 2006).

Previous research in education suggests that to enhance student motivation, persistence, and the willingness to work collaboratively, it is necessary for the students to develop a network of support, especially support provided by their peers (Kinnunen & Malmi, 2006, Waite & Leonardi, 2004). However, students find it difficult to create and maintain such support networks on their own. Helping students create such peer support networks is a task educators must shoulder. It has been shown that interacting with peers fortified the learning process and made learning more enjoyable (Perez-Prado & Thirunaraanan, 2002; Swan 2002).

To help educators to help their students, we have developed an online social network learning system called *PeerSpace*. *PeerSpace* integrates a suite of Web 2.0 tools to promote student interactions. Using *PeerSpace*, students are able to communicate with each other synchronously and asynchronously on course-related materials as well as social matters. The virtual environment provides an improved vehicle that better suits the busy study and work schedules of today's college students. It expands student interactions and activities beyond the face-to-face classroom to the online environment and provides infrastructure to help students build peer support networks. Beyond social networking, *PeerSpace* provides specific tools for conducting peer collaborative learning activities. Peer collaborative learning refers to the use of teaching and learning strategies in which students learn with and from each other without the immediate intervention of an instructor (Boud, Cohen, & Sampson, 1999). Studies report that peer learning promotes greater conceptual and procedural gains for students, accommodates a broad range of learning styles, results in greater enjoyment of the learning task, and encourages a stronger persistence in learning.

Related Work

PeerSpace is developed based on earlier work done on Peer Collaborative Learning (PCL) applied to computer science education and developments in Computer Supported Collaborative Learning. In PCL, student learning is enhanced through peer/classmate interactions that occur when students discuss course-related materials and complete assignments as a group (Beck & Chizhik, 2008), teach each other course-related materials (Huss-Lederman, Chinn, & Skrentny, 2008). PCL techniques have been used in introductory computer science courses resulting in reports of higher student achievement, more positive attitudes toward the subject, improved student retention, improved student interaction and communication skills.

One focus of work in Computer Supported Collaborative Learning (CSCL) has been to develop, adapt, use, and assess online tools that support collaborative learning. Online communication tools, such as online discussion forums, blogs, and wikis, and real-time chat rooms, have been adapted and investigated as ways of promoting collaborative knowledge building among students (Bhagyavati, Kurkovsky & Whitehead, 2005; Lee,

2006). Researchers have found that online discussion enables students to participate in collaborative sharing and creating of knowledge. Being involved in an online discussion group improves communication and collaboration skills, encourages lifelong learning (Barker, 2003), increases student participation and achievement of learning outcomes, accelerates the generation of learning communities (Bhagyavati, Kurkovsky & Whitehead, 2005) and leads the knowledge construction process to higher phases of critical thinking (Aviv et al; 2003). Blogging improves student comprehension because they must “synthesize information, formulate additional questions, contrast and make sense of differing viewpoints, and identify patterns and trends” (Karrer, 2007) when posting information. Wikis transform the one-to-many model of knowledge transfer into a collaborative, many-to-many network where students, teaching assistants, instructors can contribute to the knowledge of the group.

A second focus of work in Computer Supported Collaborative Learning is centered on developing and assessing strategies for building online learning communities. An online learning community (Goggins, Laffey, & Tsai, 2007; Misanchuk, 2001) is a group of people, sharing some set of common values and beliefs, who are actively engaged in learning together from each other on the web. To “build” an online learning community is to build the students’ sense of community, social identity, and trust through some form of group activities (Ching et al., 2005).

The *PeerSpace* System

A premise of *PeerSpace* is the belief that combining the methods and tools of PCL and CSCL will have an even stronger positive impact on student learning than either alone. By doing this, peer collaborative learning activities developed for CS education can be extended from the physical to the online world. This consequently minimizes scheduling costs, the amount of time and effort needed to organize face-to-face group meeting, that are often quite high in typical introductory CS courses due to the large percentage of the students working many hours off campus. In addition, the ideas of online social networks can be incorporated into the integrated system to enhance student interactions and facilitate the building of peer support networks among students. In such a system, peer collaborative learning activities encourage students’ participation in the online social networks, whereas online social networks make it easier for students to support each other academically and socially.

The goal of *PeerSpace* is to promote peer collaborative learning in introductory CS courses by providing carefully designed peer collaborative exercises within a friendly, peer-supportive online social network environment, and to facilitate the building of peer support networks that last throughout and beyond the introductory CS courses. The *PeerSpace* system has two main components: a social network component and a peer-learning component. The social network component enables the building of peer networks and trust, and fosters a feeling of learning community membership---these are essential elements for effective collaborative learning. This component provides a variety of tools to support asynchronous and synchronous peer communication.

The collaborative-learning component is comprised of a set of carefully designed peer learning activities that include group discussion, peer tutoring, and peer assessment. The shared knowledge these activities instill affords the students a deeper understanding of course-related concepts and a broader knowledge of course-related topics. Moreover, these collaborative peer-learning activities strengthen the support among peers and expand a student’s social network.

PeerSpace is developed based on Elgg (www.elgg.org), an open source social network engine. The *Elgg* engine comes with a number of basic features, some of which are directly incorporated into *Peerspace*. These include:

- User profile: Allows students to share their personal information such as the profile icon, interests, email, and personal web links;
- Friends: Allows students to build a personal network of peer support;
- Personal blogs: Allows a student to share their thoughts and opinions with either friends or the whole *PeerSpace* community;
- Groups: Allow group members to have private discussions.

To make *PeerSpace* an environment to foster a strong sense of community, a number of new features have been developed as additional plugin modules:

- Scoring for *PeerSpace* community contribution: To keep track of student contribution to the community, a scoring module is built that gives 1 point to each post/comment a student submits in discussion forum or blog. A logged-in student can view his and group members’ contribution;
- Widgets are developed to encourage friendly competitions among individuals and groups. The list of “top” students, i.e., students with the top community contribution scores; and the list of “active” groups, i.e., groups with the highest average member contribution scores are displayed on the front page of *PeerSpace*;
- A custom-built forum discussion module that allows hierarchical threading and thumbs up and down voting;

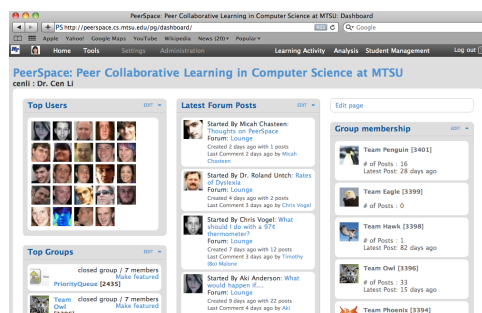


Figure 1. A Snapshot of the Front Page of *PeerSpace*.

- Real-time peer-to-peer chat and group chat; and
- RSS feeds from various *PeerSpace* tools, and RSS subscriptions.

To promote collaborative learning, a number of modules have been incorporated, adapted, and developed for various learning activities. The group wiki plugin has been adapted to allow the study group members to collaboratively design algorithms for group programming assignments. It has also been used for group homework assignments consist of short answer questions and coding exercises. To help students understand basic concepts covered in lectures, a student practice exercise module is built to allow students to work on multiple choice questions and true/false questions addressing the concepts. It also serves as a tool for the students to prepare for the semester tests. The students are encouraged to seek help from their group members or from *PeerSpace* community on questions concerning these exercises. A project repository module has been developed where the students can electronically submit assigned programs, as well as retrieve and view the feedbacks from instructors in *PeerSpace*.

When a student logs in *PeerSpace*, the student is presented with the *PeerSpace* front page, shown in Fig. 1. The front page displays the current community status in the form of the latest blog and forum posts, current online users, and group membership information. Also displayed are items designed to promote collegial competition among students: ranked listings of the top students and the most actively participative groups.

The concept of “group” is an essential feature of *PeerSpace*. It brings students with similar backgrounds and interests together, and gives them a private place for discussion and collaborative work. Group members may choose to use group discussion forum, group blog, or group wiki for their work. *PeerSpace* groups are either created by instructors for lecture/homework purpose, or created by students themselves for social purpose. An Elgg plugin called DokuWiki is incorporated by *PeerSpace*. This allows each group to construct their own wiki pages. The wiki tool enables instructors and group members to track revision history of the document maintained by the group. The DokuWiki tool also provides the built-in “code block” feature that provides an IDE-editor like view of source code for different programming languages by preserving the format and the color pattern. With the support of DokuWiki, it is easier for group members to work collaboratively on a document that may contain the solution to group homework; and instructors and group members can easily identify the contribution from each group member and observe the discussion process of constructing the solution.

Experiment

In evaluating the effects of using *PeerSpace*, there were two facets we wished to examine in particular:

1. the effectiveness of *PeerSpace* in helping the students avail themselves of a peer support network where students help one another and work collaboratively in small groups on class assignments; and
2. the effectiveness of this collaborative learning environment in better motivating the students and in improving student learning of course material.

During the Fall 2010, a preliminary experiment of *PeerSpace* was conducted on two CS1 sections that were taught in the traditional lecture format by the same instructor using the same textbook. One section of 23 students is designated the experiment group, and the other section of 20 students is the control group. The students in both sections have been put into study groups of 5-7 members. The groups were formed by the students voluntarily at the beginning of the semester. The students in the experiment section were exposed and required to use *PeerSpace* for their group activities, while the students in the control section didn't use *PeerSpace*.

To help students learn the tools provided in *Peerspace*, the students in the experiment section were required to work on 3 mini-labs. In the first lab, the students created their profile pages, wrote blogs commenting on news articles about the current technologies in the field of Computer Science, and posted or commented on discussion forum posts. In the second lab, the students get familiarized with other members of their study group by sharing their outside class interests in the group discussion forum. In addition, each group

jointly created a fictional story using the group wiki tool. In the third lab, the students practiced online peer-to-peer chat, and group chat using the “virtual” group chat rooms. They also learn to subscribe to RSS feeds from *PeerSpace* announcements, forum discussions and group discussions.

Throughout the semester, the students in both sections work with his/her study group members on group assignments to design computer programs collectively, or come up with a group solution to homework. The group assignments were given weekly. The students in the experiment section have full access to *Peerspace* so that group members can collaborate with each other synchronously or asynchronously. The students in the control section mainly did pencil and pen, face-to-face collaboration. Due to physical constraints and the busy and varying schedule of all the students, the control group of students had a significantly lesser amount of time working together on these projects.

Some of the *PeerSpace* student activities are not monitored and measured directly, for example, the number of times a student initiates online chat with others in their group, or the length of the chat. Other activities are monitored and measured, for example the number of contributions each student makes in the *PeerSpace* community in terms of the number of forum discussions, blogs, and comments posted. By mid term in Fall 2010 semester, the number of posts generated by the experiment group students range from 1 to 27, with a mean and standard deviation of 9 and 6 respectively.

To measure the students’ perceptions as a member of the *PeerSpace* learning community, questionnaire developed based on (Carron, Widmeyer & Brawley, 1985) and (Rovai, 2002) has been used in this study. Questions from (Carron, Widmeyer & Brawley, 1985) have been slightly reformulated to make it better suited for an academic environment and more geared towards group activities for CS students. All the questions are Likert scaled questions with a value 1 representing “strongly agree”, and 5 representing “strongly disagree”.

The two-tailed sample t-test was performed comparing the mean values between the experiment and the control group responses to all 38 questions. The mean response values of all the 38 questions from the experiment group all show a positive or neutral trend. T-test reveals that the mean values of student responses along six questions are statistically significant, with a p value less than 0.1. These six questions are:

- Q1. I feel that students in this class care about each other.
 Q2. I feel connected to others in this class.
 Q3. I trust the others in this class.
 Q4. I feel that other students do not help me learn.
 Q5. Class members help one another.
 Q6. Class members rarely interact with another.

Table 1 shows the t-test statistics of the student responses from the experiment and the control groups along these six questions. These results show that, compared to the control group of students, the students in the experiment group have a much closer relationship with fellow students in the class. They are much more trusting of each other, caring of each other, and much more willing to help the others in the class and collaborate on course work.

Table 1: Two-tailed T-test statistics on the experiment and control sections.

	Questions					
Mean (Std. Dev.)	Q1	Q2	Q3	Q4	Q5	Q6
Experiment Section	2.39(0.94)	2.52(0.79)	2.26(0.86)	3.9(0.82)	1.739(0.86)	4.04(0.82)
Control Section	3.1(1.25)	3.2(0.89)	2.9(1.2)	3.3(1.34)	2.3(1.2)	3.5(1.05)
T-Test p value	0.045	0.012	0.057	0.067	0.087	0.07

Table 2: Test results on the experiment and control sections.

	Tests	
Mean (Std. Dev., Sample size)	Test 1	Test 2
Experiment Section	74.2 (16.3, 27)	75.4 (17.8, 26)
Control Section	70.8 (25, 23)	70.7 (24.8, 19)
T-Test p value	0.29	0.45

The other aspect of the evaluation focuses on assessing the effectiveness of the *PeerSpace* learning community in motivating the students to learn course materials. The question of interest is: do more collaborative learning activities lead to better learning of course materials, as measured by the test scores? Table 2 shows the results and statistics data of two tests given in the semester. It is seen that the experiment section was able to obtain a higher mean test score than the control section on both tests. Even though the two-tailed sample t-test values, 0.29 and 0.45, indicate the observed higher mean test scores are not statistically significant with $p=0.1$, the instructor of the two sections reported a better overall learning motivation and attitude from the students in the experiment section. More experiments and studies are needed to capture the differences in learning outcome attributed to *PeerSpace*.

Conclusions

Entry-level Computer Science courses currently suffer from unacceptably high dropout and failure rates. The stereotype image of the computer science student working away on a computer, alone in isolation, is pervasive. This unfortunate perception leads to less motivation for the students and less willingness to support and help fellow students and to work collaboratively that in turn worsens the study environment. The work presented in this paper attempts to change this stereotype study environment by building an integrated online collaborative learning community. Far from being isolated, the students are encouraged to involve in social interactions with fellow students, exchange ideas, help each other on understanding course materials, and engage collaboratively on course work. To facilitate online social interaction and collaborative work, a suite of web tools have been adapted and developed in this community. Initial experiments with students enrolled in the Fall 2010 semester have shown promising results where the students show a stronger attachment to their fellow students, more willingness to help and work with others in the same class, as well as an overall improved learning performance.

References

- Aviv, R., Erlich, Z., Ravid, G., and Geva. A. (2003). Network analysis of knowledge construction in asynchronous learning networks. *Journal of Asynchronous Learning Networks*. 7(3), 2003.
- Barker, S. (2003). Online discussion boards: impacting the learning experience. Proceedings of the *Fifth Australasian Conference on Computing Education - Volume 20*. Adelaide, Australia, 2003.
- Beck, L. & Chizhik, A. (2008). An experimental study of cooperative learning in CS1. Proceedings of the *39th SIGCSE Technical Symposium on Computer Science Education*.
- Bhagyavati, Kurkovsky, S., & Whitehead, C. (2005). Using asynchronous discussions to enhance student participation in CS courses. *ACM SIGCSE Bulletin* 37(1), 2005.
- Boud, D., Cohen, R., & Sampson, J. (1999). Peer learning and assessment. *Assessment and Evaluation in Higher Education*, 24(4), 413-426.
- Carron, A.V, Widmeyer, W.N., & Brawley, L.R. (1985) "The development of an instrument to assess cohesion in sport teams: the Group Environment Questionnaire", *Journal of Sport Psychology* 7: 244-66.
- Goggins, S.P., Laffey, J., & Tsai, I. (2007). Cooperation and groupness: community formation in small online collaborative groups. Proceedings of *GROUP'07*. 207-216.
- Karrer, T. (2007). Learning and networking with a blog. *T+D magazine*, September 2007.
- Kinnunen, P., & Malmi, L. (2006). Why students drop out CS1 course? Proceedings of the *2006 International Workshop on Computing Education Research* (Canterbury, United Kingdom, September 09 - 10, 2006). ICER '06. ACM, New York, NY, pp. 97-108. 2006.
- Hanks, B., McDowell, C., Draper, D., & Krnjajic, M. (2004) Program quality with pair programming in CS1. Proceedings of *ITiCSE 2004*, 176-180, 2004.
- Huss-Lederman, H., Chinn, D., & Skrentny, J. (2008) Serious fun: peer-led team learning in CS. *ACM SIGCSE Bulletin*, 40(1), 2008.
- Laraqui, J. (2007). Activity based interfaces in online social networks. *Master's thesis*. Department of Electrical Engineering and Computer Science, MIT. 2007.
- Lee, S.W. (2006). The interplay between self-directed learning and social interactions: collaborative knowledge building in online problem-based discussions. Proceedings of the *7th International Conference on Learning Sciences*. 390-396.
- McKinney, D., & Denton, L.F. (2005) Affective assessment of team skills in agile CS1 labs: the good, the bad, and the ugly. Proceedings of *SIGCSE '05*. 465-469.
- Misanchuk, M. (2001). Building community in an online learning environment: communication, cooperation and collaboration. Proceedings of the *6th Mid-south Instructional Technology Conference*.
- Perez-Prado, A., & Thirunaraanan, M. (2002). A qualitative comparison of online and classroom-based sections of a course: Exploring student perspectives. *Educational Media International*, 39(2), 195-202.
- Rovai, A.P. (2002) Development of an instrument to measure classroom community. *The Internet and Higher Education*. 5:197-211.
- Simon, B., & Hanks, B. (2007) First year students' impressions of pair programming in CS1, Proceedings of the *Third International Computing Education Research Workshop*, 73-85, Sept..
- Swan, K. (2002). Building learning communities in online courses: the importance of interaction. *Education Communication and Information*, 2(1), 23-49.
- Waite, W. M., & Leonardi, P. M. (2004). Student culture vs. group work in computer science. Proceedings of the *SIGCSE '04*, March 3-7, 2004, Norfolk, VA, USA. pp 12-16.

Acknowledgments

This work is funded by the NSF CCLI grant (DUE-0837385), NSF REU grant (IIS-1038172), and an internal grant from the Sponsored Research Program at MTSU.

The Role of Different Narratives in Recognizing Peer Expertise in Collaborative Programming Projects

Deborah A. Fields, Yasmin B. Kafai, University of Pennsylvania, 3700 Walnut Street, Philadelphia, PA 19104
Email: defields@upenn.edu, kafai@upenn.edu

Abstract: Much research has focused on identifying the role that various factors play in promoting interest and access in broadening participation in computing. Few studies have examined what happens once access is no longer the issue and the focus shifts to negotiating participation in collaborative programming activities. Peer experts, youth knowledgeable in programming, play an important role in providing assistance in group collaborations. In this paper, we examined two youth peer experts through a practice lens on identity with self- and others'-narratives to understand better what it means to gain recognition as a peer expert in a community. Our analyses suggests that becoming an expert involves acting and being received as such in practice, thinking about oneself as an expert (self-narrative), and having other people think about oneself as an expert (others'-narratives). We discuss these findings in terms of implications for supporting peer collaboration in computer supported collaborative learning.

Introduction

In this paper we address the issue of how expertise travels and what it means to gain recognition as a peer expert as a programmer in a local classroom community. More specifically, we focus on how young software designers develop personal agency with programming, move toward membership in a programming community, and gain status as experts amongst their peers. Rather than using peer or teacher ratings, we use an identity lens to understand how peer expertise is established in the context of a classroom community. This approach adopts a multi-faceted perspective by focusing on an individual's sense of self in creating things (Black, 2006), centralized participation amongst a group of people (Lave & Wenger, 1991), and how individuals are socially recognized by others (Gee, 2000/1). As part of a larger study researching youths' participation across multiple social settings in their lives, we focused on two case study youth and their interactions in small group projects during a 3-week, 6-session unit using a visual computer programming platform called Scratch in their 6th grade math class. Despite the youths' prior experience in Scratch and explicit positioning by the teacher as "experts," their peers rejected the more valuable expertise that they brought to the projects for several days. Through close video analysis of small group interactions, this analysis demonstrates the challenges the two youth encountered in being recognized in practice as being experts among their peers and the contrast in productive collaboration that occurred after their peers realized that the youths' knowledge was valuable to the project creation. At the end we discuss implications for supporting peer collaboration in computer supported collaborative learning.

Background

We draw on situated identity research to develop a framework to see becoming a peer expert as a set of interwoven *practices*: being 'named' as such by others, adopting a formal idea of oneself as an expert, and acting in social interaction. This framework is drawn from a situated meaning of identity that focuses on an individual within local social interaction (e.g. Lave & Wenger, 1991). This situated perspective frames people as acting in ways to position themselves relative to others in a local social setting, in other words we see identity at the intersection of the individual and the social (Holland, Lachiotte, Skinner & Cain, 1998). People neither have full ability to author themselves nor do others have full ability to position them; identity is iteratively shaped moment by moment over time through negotiations in social interaction. This means that being a programming expert cannot solely rest inside a person's idea of him- or herself. Instead, being an expert must be socially negotiated.

Further, we argue for three complementary lenses on identity: local acting and positioning in *practice*, the ways one thinks of oneself (*self-narratives*), and the ways that others think of one (*others'-narratives*). These lenses are mutually constitutive, and each builds on the others in interactive ways. A practice lens on identity accounts for the ways that a person's identity is both stabilized and changed during the course of interaction - how a social situation defines or constructs identity through practice and how an individual disrupts such construction through their actions (e.g. Wortham, 2006). A narrative lens on identity emphasizes self-understanding in the shape of narratives one tells about oneself. In particular Sfard and Prusak (2005) suggest defining identities as sets of narratives, "as collections of stories about persons or... as those narratives about individuals that are *reifying*, *endorsable*, and *significant*" (p. 16, italics in original). In this they suggest paying attention to the stories people tell about themselves or that others tell about them that influence 'who they are.' Here we draw together a practice lens on identity with self- and others'-narratives as further lenses on identity.

From this framework, becoming an expert involves acting and being received as such in practice, thinking about oneself as an expert (self-narrative), and having other people think about oneself as an expert (others'-narratives).

In the context of this paper, the two youth studied faced a situation where they had knowledge of programming that their peers did not and their teacher explicitly provided an others'-narrative that they were peer programming experts in front of the entire class. Despite this, they were not initially accepted as such by their peers, at least not in ways that would have allowed them to share valuable insights into programming. Previous research has shown that such students can be of great benefit in collaborative programming when teams are composed of both experienced and novice software designers (Ching & Kafai, 2008). The emerging informal "peer pedagogy" illustrates how those more advanced programmers are able to support and monitor their less experienced peers in programming design, with an eye towards facilitating rich learning experiences for the beginners. It is often assumed that others easily recognize such expertise. Indeed, age and status are often well established in classroom communities. Yet it is unclear how the process of negotiating expertise takes place within teams and what kinds of resources the more experienced designers draw upon in interactions. Further, in this paper we illuminate challenges in the recognition of peer expert status that impede such more expert peers from helping novice peers in useful ways.

Context and Methods

This study is based on a larger connective ethnography (Leander, 2008) of the two focus youth, Tyrone and Lucetta (both pseudonyms), across many social settings of their lives. Data collection drew from the three-pronged approach, including observations of a preceding after-school Scratch Club, the three-week Scratch Class, and across other subject areas at school and activities at home or with friends (practice); surveys of computing attitudes and monthly interviews with the youth (self-narratives), and careful attention to how others talked about the youth (others'-narratives). In addition we also collected their Scratch programs daily throughout the Club and the Class in order to analyze their developing skills as programmers. Though the focus of this paper is on the Scratch Class, analysis of the youths' participation in other settings provided information on how the youth learned Scratch, how they acted amongst their peers, and their typical kinds of participation in different subjects at school.

Two classes of twenty sixth-grade students each participated in using Scratch during a three-week unit in their math class in Spring 2008. In discussions with the teacher, the researchers designed a six-day unit where students made geometric art projects in math class to accompany a more general introduction to geometry. When possible, students with prior experience with Scratch were paired with the students who had no experience with Scratch. The projects involved a cycle of development, revision, and final presentations. During the first four days, students created the geometric art projects. At the end of the fourth day, they uploaded their projects to the Scratch website where students received constructive comments on their projects. At the beginning of the fifth day students eagerly went online to see their comments and engaged in a day and a half of intense revisions before presenting their projects to the rest of the class at the end of the sixth day.

Data analysis focused on the six days of kids' designing with Scratch in the class. Using an iterative video analysis approach (Erickson, 2006), we divided videos into short 1-2 minute interaction chunks and developed a two-step open coding based on grounded theory (Charmaz, 2000). Two categories emerged for the kind of programming and problem solving comments given by Tyrone and Lucetta: "procedural" suggestions and "conceptual" suggestions. "Procedural" suggestions refer to lower-level comments about single pieces of code and their functions. "Conceptual" suggestions refer to higher-level comments about the relationship *between* sets of scripts such as identifying conflicts and using sophisticated commands to link sets of scripts (loops, conditionals, and others). Below we describe how initially there was an underlying conflict between the novices' low-level comprehension of programming that focused on procedural understanding and Tyrone and Lucetta's higher-level comprehension that focused on conceptual understanding of the scripts.

Findings

Though both Lucetta and Tyrone came to the Class with prior experience in programming from an after-school Club, the partners in their groups did not recognize them as peer experts for several days. Instead, as we will demonstrate, the partners solicited and accepted low-level, procedural help while rejecting the higher-level conceptual help that both youth offered in the context of the programming projects. Though one might be inclined to think it was a problem of social personality, the lack of recognition exhibited itself despite very different ways of working within small groups. Below, we briefly describe Lucetta and Tyrone's prior experiences with programming, then move to illustrate the ways that their peers rejected their relative expertise with programming, how or when the peers shifted to recognizing Lucetta and Tyrone as peer experts, and the effects of this recognition on the small groups' projects.

Framing as Peer Experts in the Class

Both Tyrone and Lucetta were new to programming and most forms of digital design when they learned to use Scratch during the eight weeks of an after-school Club earlier in the Spring of that same year. By the end of the Club they had learned to use a number of scripts in Scratch, had worked on several projects, and had used the Scratch website to post, download, and remix projects. Though no one at the Club stood out as having any more expertise than others because they had all been learning to use Scratch for roughly the same period of time, this changed in the Scratch Class. The teacher (Ms. Franklin) and researchers purposefully framed students who had prior experience as “Scratch experts” and encouraged students to seek out help from them before asking the adults. In this way the teacher provided an others’-narrative to the experienced students by giving them the title of “expert” and directing them toward practices of teaching the “novice” students. The others’-narrative of being a peer expert in Scratch was a resource for identity development. Yet though the others’-narrative was backed by the teacher’s authority in the Class, by itself it was not enough to get the students to see Tyrone and Lucetta as peer experts.

Shifts in Identifying Tyrone and Lucetta as Peer Experts

At first sight, it appeared that because of personality differences Tyrone got along poorly with his partners while Lucetta got along perfectly with hers. In school Tyrone tended to ostracize peers outside of his close group of “geek” friends through his sarcastic sense of humor, especially girls. This applied to the girls who were his partners; he tended to explode in frustration when they did something he saw as incorrect and spoke in a negative, sarcastic manner about their mistakes. In contrast, Lucetta was a peacemaker among her friends and in the larger Class, reaching out to students who tended to be alone. Lucetta put her partner’s interests first, making polite suggestions for things that they could do but generally following her partner’s desires for the direction of the project. Yet despite these personality differences, whenever Tyrone or Lucetta offered conceptual level suggestions (invited and uninvited), their peers either ignored, argued against, or deflected the suggestions. For the first few days, only procedural answers were invited and accepted by their more novice peers.

For Tyrone, the small group interactions changed on the third day of the Scratch Class when he exploded with frustration. He stood up, interrupted his partners’ planning conversation, and pointed to a command on the screen that was interrupting a series of commands and preventing the project from working. His partners, Carissa and Diana ignored his first attempt. When he tried again half a minute later, his voice rose and he elongated his words, emphasizing the code that was conflicting with others codes. Finally, one of his partners suggested taking a related command out, to which Tyrone agreed and Carissa finally seemed to understand that the codes were not needed for the project. This was the first time Carissa showed some understanding of the kind of interaction between scripts that Tyrone had repeatedly pointed out. This moment of intersubjectivity where Tyrone’s partners finally seemed to understand the value of what he was saying for the project was a turning point in the group’s collaborative activity.

Lucetta experienced a more quiet turnaround when her partner, Candy, began to recognize her as an expert on the fifth day of the Class. Earlier Candy had ignored Lucetta’s suggestions, often saying they should just give up and start the project over. After they received online feedback on their project the girls played around with ideas for improving it, and at one of Lucetta’s suggestions Candy replied in surprise, “Do you know how to do that?” This question points to the beginning of Candy’s realization that Lucetta could accomplish desirable things in Scratch, a quiet turning point in their small group interactions. Throughout the remaining two days of the Class the two girls expressed excitement and problem-solved together, with both contributing to the building of the project in ideas and in the construction of scripts. Candy accepted all of Lucetta’s suggestions, treating Lucetta as more of an expert.

Changed Interactions in Project Design

Despite their newfound acknowledgement of Tyrone’s suggestions, Carissa and Diana did not straightaway implement his advice about taking out unnecessary scripts, so they did not see an immediate affect on their program. Still, their attitude toward him changed during this interaction. For the rest of period, rather than ignoring his uninvited suggestions, they responded to and implemented his advice. Understanding the need to make a set of scripts agree with each other seemed to lead to new respect for Tyrone’s expertise. The group proceeded to work on their complex project. Later the girls responded more quickly to Tyrone’s suggestions. They also began to include him in talk about the project, turning their heads to physically include him in their discussions of what they wanted to happen. Tyrone even made them laugh on occasion with his comments, further signaling his increasing inclusion in the group. In fact, Tyrone became a better teacher of Scratch, not just telling his partners what they should do, but explaining why things worked in certain ways, what effects some of their decisions would have, and what kinds of possibilities there could be in the program if they added certain sets of scripts. Still, sometimes Carissa and Diane ignored Tyrone’s legitimate programming suggestions. In these situations Tyrone sometimes referred to a local authority – the researcher or another peer who had a higher reputation with programming – to back up his own instruction, again, in a sense creating his

own others'-narrative that supported his idea of himself as a peer expert. Thus Tyrone leveraged several narratives in pushing for recognition of his programming expertise: his own, his teacher, the researcher, and a more recognized peer expert. Further, his two partners now treated him as an expert in practice with positive results for their project.

In the small group interview after the Class, Tyrone and his partners reaffirmed this new narrative of Tyrone as an expert. Carissa and Diana said that it helped to ask Tyrone about things when they were stuck because "he's the expert," explicitly stating an others'-narrative of Tyrone as an expert. They also recognized that they learned to listen to Tyrone during the Class, who himself said that he learned "to be a better leader" and "It kinda felt like leadership skills - because I can naturally use the computer," echoing his teacher's comment from the first day that he was "the leader" in his small group. Consequently there were matching self- and others'-narratives about Tyrone as an expert/leader in programming in the Class.

Again, the case of Lucetta is less obvious than that of Tyrone. Though there had been an underlying conflict between Candy's novice understanding of programming and Lucetta's more sophisticated awareness, this conflict remained tacit because Lucetta did not explicitly appropriate Ms. Franklin's others'-narrative that she was a Scratch expert. Though she gently pressed on in her desire to make the project more complex and fix underlying problems, she often deferred to Candy and did not make loud exclamations of frustration when Candy ignored, argued against, or gave up on her comments. This was typical of a peacemaking role Lucetta took up in other areas of her life. Though Candy treated Lucetta differently in practice, she did not express succinct others'-narratives of Lucetta as an expert. The closest she came was in the interview after the Class, where Candy expressed, "Lucetta's really good with Scratch, so I think it helped me to become better with Scratch because I had never done it before." Here Candy provided others'-narratives that expressed respect for Lucetta's knowledge of programming in Scratch. Yet why did Lucetta not reiterate some of the most authoritative others'-narratives about her, such as that given by Ms. Franklin at the beginning of the Class? Perhaps because Lucetta already acted in a non-bossy, shepherding role and got along well with her partner, Ms. Franklin did not reiterate an others'-narrative of being an expert or leader to Lucetta as she had with Tyrone. Lucetta herself did not demonstrate Tyrone's frustration with developing a self-narrative as an expert, or at least of getting others to recognize her that way. Consequently though Lucetta acted like a peer expert with her higher level knowledge and was tacitly acknowledged as an expert in practice, the narratives of her as a Scratch expert were less succinct and clearly formed.

Discussion

In this paper, we focused our attention on the recognition of peer expertise in collaborative programming projects. Despite their teacher's publicly positioning them as experts and regardless of differences in how their small groups worked interpersonally, both Tyrone and Lucetta struggled to be recognized for their prior programming expertise with implications on their small groups' collaborative work.

We start our discussion by reflecting back on the use of three identity lenses to understanding peer expertise recognition. By understanding how students positioned themselves and how others (the teacher and peers) positioned them, we were able to better understand the coordination between different narratives, those of self and others. Most importantly, this highlights that recognition of peer expertise is not a one-way street but a process based on mutual recognition. For instance when Tyrone proclaimed that he learned "to be a better leader" it also coincided with his peers accepting his suggestions. Further, achieving status as a peer expert involved interactions amongst narratives by various others (the teacher, Tyrone's better known expert peer, small group partners), self-narratives by the two case study youth, and interactions in local practice where knowledge was shared and responded to within the small groups. Studying these three lenses allowed us to see relationships between self- and others'-narratives (e.g. between Ms. Franklin's narrative of Tyrone as an expert and leader and Tyrone's subsequent appropriation of these narratives with his peers) and between narratives and practice (e.g. between Ms. Franklin's narrative of the two youth as experts and their peers' treatment of them).

The study also highlights that while narratives are powerful artifacts in authoring people (both self and other), individuals also have power in determining which narratives to appropriate for themselves. One question raised in the study is why Tyrone appropriated and advertised the narrative of himself as a peer expert while Lucetta did not. Observations from the larger study suggest that one motivation for Tyrone was being a part of a "geeky" group of boys who prided themselves on producing with computers. In fact, Tyrone was the least competent of these friends in terms of creating media with computers, and his developing expertise with Scratch allowed him to participate at a deeper level with his peers. In contrast, Lucetta let the idea that she was an expert sit quietly in the background rather than brokering that narrative herself. She did not actively assist in the travel of this narrative with her partner and it did not appear to make as much of an impact in her life. One influence was likely the idea that she already thought of herself as more proficient in using computers than her family and friends, and her friends seemed to care more about social uses of computing (email and chat) than creating with computers. Another influence may be a gendered role she often took up with her friends and family, leading by supporting others' interests rather than her own. This points to the further complexity of motivations and

interests behind youths' appropriation of narratives.

The improved collaborative work on the programming projects illustrated here is further evidence that promoting peer pedagogy can be a productive way to facilitate computer supported collaborative learning and broaden participation in digital design practices. Of note, while the novices learned more about programming, Tyrone and Lucetta also deepened their knowledge of programming, using more complex scripts such as conditionals that they had not used in prior projects. Lucetta went so far as to say that Candy's ideas for the project had pushed her to develop some of this new programming expertise, commenting that they were not ideas she would have come up with on her own. It appeared that both youth were pushed deeper by working out some of the ideas their more novice peers expressed but did not know how to make happen.

Our paper is a complement to Ching and Kafai's (2008) paper on peer pedagogy that focused exclusively on how experts, as defined by age and experience, interacted with their younger peers in class. In their study, expertise was defined by having had prior programming knowledge from students' former year in a 4th/5th grade class, thus overlapping expertise with age. Our findings show some complications that can arise when the peer experts do not have outside status. Taking place in a single age classroom, Tyrone and Lucetta were not older than their peers nor did they have prior histories (narratives) of themselves as programmers with the other students in the sixth grade. Except for their teacher's statement calling them programming experts, they had little status to back up the suggestions that they made, even though their conceptual level suggestions were valid and helpful. Further research is needed to show whether peers who had more locally known histories as programmers or related experts would be able to provide higher level help without rejection by their partners. This research raises the question to what degree was the lack of peer recognition of Tyrone and Lucetta's relative expertise due to status or to an inability of more novice programmers to recognize the value of concepts with which they were unfamiliar.

In this paper we have illuminated some of the social and cultural barriers that can arise in helping youth develop identities as programmers and in using peer pedagogy to promote collaborative learning of programming. The learning evidenced in the groups' projects suggests peer pedagogy is a promising area in terms of learning programming, though the developing social interactions within the groups suggest that the path toward peer recognition, while important for collaborative learning, is potentially rocky. The complex interplay of narratives and practice reveals challenges in broadening participation in programming and promoting youths' identities as programmers with teachers and peers.

References

- Black, R.W. (2008). *Adolescents and online fan fiction*. New York: Peter Lang.
- Charmaz, K. (2000). Grounded theory: objectivist and constructivist methods. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 509–535). Thousand Oaks, CA: Sage.
- Ching, C. C., & Kafai, Y. B. (2008). Peer pedagogy: student collaboration and reflection in a learning through design project. *Teachers College Press*, 110 (12), 2601-2632.
- Erickson, F. (2006). Definition and analysis of data from videotape: Some research procedures and their rationales. In J. Green, Camilli, G., & Elmore, P. (Ed.), *Handbook of complementary methods in educational research*. (3rd ed.) American Educational Research Association.
- Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (2001). *Identity and Agency in Cultural Worlds*. Cambridge, MA: Harvard University Press.
- Lave, J. & Wenger, E. (1991). *Situated learning and legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Leander, K. M. (2008). Toward a connective ethnography of online/offline literacy networks. In D. Leu, J. Cairo, M. Knobel, & C. Lankshear (Eds.) *Handbook of research on new literacies*. New York: Erlbaum, 33-65.
- Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher*, 34(4), 14-22.
- Wortham, S. (2006). *Learning identity: The joint emergence of social identification and academic learning*. Cambridge: Cambridge University Press.

Collaborative Problem Solving Processes in a Scenario-Based Multi-User Environment

Shannon Kennedy-Clark, Kate Thompson, Centre for Computer Supported Learning and Cognition,
University of Sydney, Sydney, Australia,

Email: shannon.kennedy-clark@sydney.edu.au, kate.thompson@sydney.edu.au

Debbie Richards, Computing Department, Macquarie University, Sydney, Australia,
deborah.richards@mq.edu.au

Abstract: This paper presents the results of a study aimed at gaining an understanding of the process that groups use to solve scientific inquiry problems in a scenario-based multi-user virtual environment. In this study, 12 university students worked in pairs to complete either a structured or unstructured problem in a virtual environment. The pairs were recorded using screen-capture software. The data was coded using a modified decision function coding scheme. The results of the study indicate that participants in the unstructured activity were less likely to arrive at an outcome. Moreover, participants spent more time implementing navigation goals than implementing inquiry-based goals. Overall, the results indicate that scaffolding that supports orientation processes should be incorporated into collaborative problem solving activities in a virtual environment.

Introduction

This paper presents the findings of a study on collaborative problem solving in a scenario-based Multi-User Virtual Environment (MUVE). Scenario-based MUVEs such as *Quest Atlantis* and *River City* have been shown to both motivate and engage students (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005) yet little is known about how students collaboratively solve problems within these environments. While these environments present learners with collaborative elements of group work, such as shared goals, distribution of tasks, different roles and planning, these roles are not intuitive and students often need to have direction in managing group performance.

Virtual Singapura was the scenario-based MUVE used in this study. A MUVE, such as *Virtual Singapura*, can afford students the opportunity to visualize and engage with an inquiry-based problem in a setting that is motivating and engaging. As with most computer games, a scenario-based MUVE is underpinned by a narrative that forms the basis of the learning. *Virtual Singapura* is set in 19th century Singapore and is based on historical information about several disease epidemics during that period. In this study, the students worked in teams in order to solve the problem of what is causing the illnesses and to develop appropriate inquiry skills such as defining the scope of the problem; identification of research variables; establishing and testing hypotheses and presentation of findings.

Language and social interactions are considered to be the building blocks of social order and conversation analysis is the study of the structure and formal properties of language in consideration of its social use (Coulon, 1995). The study focused on how users collaboratively attempted to solve an inquiry-based science problem in a virtual environment. The purpose of the trial was to gain an understanding of how users collaborated to solve a structured problem compared to those given an unstructured problem. The study used a modified version of the Decision Function Coding Scheme (DFCS) (Poole & Holmes, 1995) to code the conversations of dyads in both groups. The DFCS was used to provide detailed information about the processes that participants undertook to navigate around the virtual world in order to complete the given activities. The study was aimed at identifying what the participants focused on during the task and to identify barriers to the completion of the activities.

Analysis of Collaborative Decision Making Processes

The paper analysed the verbal conversation data collected with pertinent interaction data as part of a suite of simultaneous audio, visual and screen recordings. In this study, participants interacted with a complex environment where there were multiple routes to reach the solution. Through this initial analysis of the conversation between members of the dyads, we begin to gain insights into how these decision-making processes could influence a dyad's learning outcomes.

Participants

12 participants (8 undergraduate and 4 post graduate students) were recruited for the study. Five of the participants were male and seven were female. The undergraduate students were completing a compulsory unit on the use of computers in education. The postgraduate students were all completing higher research degrees in education. None of the participants had a background in science or had used *Virtual Singapura* previously.

Materials

The trial used *Virtual Singapura* as the problem solving platform. There were two versions of the problem solving activity that were based on reducing cholera. One version was a structured or guided activity (Groups 1, 3 and 5) that led participants through the virtual world and directed participants to data collection locations within the virtual environment. Participants in the guided condition were provided with a hypothesis upon which to base their data collection in order to reduce the incidence of cholera. The second version was an unstructured problem solving activity (Groups 2, 4, and 6). Participants in this condition were not provided with a hypothesis and were not provided with instruction on where to collect data. Both sets of activities required that participants made a recommendation on the basis of their data collection and analysis. Both the structured and unstructured conditions were provided with a set of introductory materials on how to collect information and use the tools within the virtual world. No additional verbal or audio material (e.g. an introductory DVD) was provided to the participants. The materials had been revised as a result of several previous trials in order to improve the clarity of the instructions and the activities.

Data Collection

The study was conducted between August and September 2010. The participants in the study were expected to complete an in-world problem solving activity during a one hour session. The participants were randomly assigned to a partner and were then given either a structured or unstructured activity. The participants were recorded using *Camtasia* screen capture software. *Camtasia* recorded the participants' in world actions (e.g. moving the mouse, changing screens, clicking on objects), a head-shot video of the pair and their audio communication.

Data Analysis

A broad analysis of this data can express whether students are evaluating or defining a problem, agreeing or disagreeing or orienting the group's process and the data can be coded to see how students collaborate when trying to solve or engage with the problem domain. The value of this, as Sawyer (2006) indicates, is that to date, very few studies have examined how collective group dynamics can impact upon a learning experience. Moreover, this rich and observable source of data represented by sounds, words and expressions can show turn-taking and subtleties of how communication and shared understanding while focusing on the activity is achieved in far greater depth than a post-intervention questionnaire or post-test (Mazur, 2004).

Video, audio and screen capture technology were used to record the students while they interacted with the virtual environments in their teams and individually. The video and screen shots were analyzed to provide detail to the verbal items. Firstly, verbal utterances and participant turn-taking were analyzed to see how students engaged with each other during the activity and to see if there were discernable differences between the structured and unstructured condition. Secondly, the screen capture software captured pertinent information about what aspect of the environment the learners were focusing on (Mazur & Lio, 2004).

Table 1: Modified coding scheme for collaborative decision making.

Code	Category	Definition
1	Problem definition	Statements that define or state the causes behind a problem Statements that evaluate problem analysis
2	Orientation	Statements that attempt to orient or guide the group's processes Statements that evaluate or reflect upon the group's progress or processes
	Solution development	
3a	Solution analysis	Statements that concern criteria for the decision making process A direct reference to the solution must be given
3b	Solution suggestions	Suggestion of alternatives
3c	Solution elaboration	Statements that provide detail or elaborate on a previously stated alternative
3d	Solution evaluation	Statements that evaluate alternatives and give reasons, explicit or implicit for the evaluations and therefore include a valuation
3e	Solution Confirmation	Statements that ask for final group confirmation of the decision Statements that concern decisions linked to immediate results
4	Non task	Statements that do not have anything to do with the decision task
5	Agreement	Agreement – response to a question or statement e.g. yeah or yes
6	Disagreement	Disagreement – response to a question or statement e.g. nah or no
7	Implementation	Undertaking agreed upon action

The six recordings were transcribed. Each turn was considered as a unit to be coded. The transcriptions were coded according to the coding scheme provided in Table 1. A modified version of the DFCS from Poole

and Holmes (1995) was adopted for the analysis of the collaborative problem solving. We selected the DFCS as it allowed for problem definition, orientation and solution development. However, we modified the coding system to include a category for implementation of a decision. Given that in this type of collaborative learning environment, the decisions were made and implemented straight away, in contrast to other environments to which the coding scheme has been applied (Reimann, Frerejean, & Thompson, 2009) in which the decisions were made in order to coordinate longer-term team work, this was felt to be an important addition to the type of patterns that were being observed. This addition reflects initial attempts to coordinate both conversational data and data from the video screen shots that were recorded. The resulting coding system has seven main categories and five subcategories. When coding the data according to the DFCS system, 7 represented implementation of a goal, in this case the implementation of a goal was often not a verbal utterance, but was reflected in an on screen action, such as teleporting or collecting data. In most of the other cases, the codes related to verbal utterances. Overall success in the problem was, in this instance, seen as arriving at a conclusion as to whether or not building new wells would stop people from getting cholera. It was expected that participants engage in several decisions in order to come to this conclusion. The data was coded separately by two members of the research team, the pair then discussed the coding, reaching final agreement rates ranging from $k = 82 - 94\%$, which is a satisfactory level of agreement (Banerjee, Capozzoli, McSweeney, & Sinha, 1999).

Results

The results are not presented in full in this paper; instead an overview of the results relating to the research question will be presented. The six recordings were transcribed and were combined with the corresponding video and screen shot data to provide a detailed account of what the groups were saying and doing while they were using the virtual world. It should be noted here that not all of the groups were successful in arriving at an outcome. The structured Groups 1 and 5 ran out of time, but were engaged in the activity in that they remained on task. Groups 3 (structured) and 6 (unstructured) completed the activity and arrived at a conclusion. However, Groups 2 and 4, which were unstructured groups, had difficulties navigating in the world. Table 2 provides an example of the coded raw data for Groups 1 and 2. The data were taken from around 9 minutes into the activity as participants had all moved beyond the initial interaction with the virtual world.

Table 2: Raw data from transcribed conversations.

DFCS	Time	Item	Speaker	Verbal	Action on screen and video
Group 1 (Structured)					
1		69	w	can I do this thing or that thing	Clicking on well in China Town
3b		70	b	I think we use this thing, there is e-coli in the water	
3e	9.00	71	w	I'm sure it works	W pulls face and sighs
2		72	w	hrrrrrrr	Samples not changing, w pulls face
2		73	b	maybe not	
2		74	w	this is ahhhhhhh	
2		75	b	c'mon	
Group 2 (Unstructured)					
1		24	c	how do we get out	whispered
5		25	j	oh yeah	both laughing
2	9.0	26	c	here we go	move to experimental condition
7		27	c	there we go	foyer teleport to new wells

After the data were coded, percentages of each code were calculated in order to see if there were similarities between the groups. It was evident from this analysis that the majority of the items were to orient or reflect upon a group's process. The results indicated that in groups that were structured there was a higher incidence of orienting the group's processes. For example in Group 1, 67% ($n = 67$) of the items were coded as orientation processes (code 2) while in Group 2, only 37% ($n = 20$) of the coded items were orientation processes.

As in other studies (for example Beatty and Nunan (2004)), participants' perceptions of the technology were important. Evidently many of the groups had difficulties locating places, people and data collection tools while in the world. This led to varying levels of frustration (see Table 2) and confusion. For example, Group 5 spent nearly five minutes trying to find the hospital and locate the doctor to interview, and when asked in a follow-up survey several weeks later about what they remembered of their in-world activity, one member of a dyad indicated that not finding the doctor was the most memorable part of the experience. Moreover, most of the participants focused on making decisions that related to navigating through the world, such as moving from one location to another rather than actually engaging with the inquiry problem. For example, Group 4 did not engage with the problem at all, they did implement decisions, but they were navigational rather than inquiry-

based. This reflects issues raised in earlier work that participants had difficulties in engaging with the problem due to the complexity of the environment and raises a series of design issues on how best to structure for learning in a scenario-based MUVE (Kennedy-Clark, 2010). Overall, while there was convergence on a desired goal state, there was little convergence on a shared understanding of the problem (Roschelle, 1992).

Table 3: Comparison of goal implementation between groups 2 and 6.

Group 2		Group 6	
2	38	g	you click on (laughing)*
2	39	c	ok, so that's the
2	40	g	yeah, the [phraser] thing
7	41	c	(right click on patient)
1	144	n	now we need another sample (looks at notes)
2	145	s	uhummmmm
5	146	n	okay
5	147	s	okay
7	148	n	four and two, okay, that's two, I think that's all (counts objects in wells)
5	149	s	yeah, okay

* Actions shown in brackets

Table 4: Example of disagreement followed by orientation.

Group 3				
12	1	32	b	hospital admissions
	2	33	g	changing seasons
	2	34	b	is that the hospital (moves mouse)*
	6	35	g	nah
13	6	36	b	no
	6	37	g	no
	2	38	b	At the map
	5	39	g	yeah (moves mouse to map)

In terms of implementing a desired goal (code 7) the unstructured Groups 2 (n = 18, 33%) and 6 (n = 61, 26%) implemented more decisions. However, examination of the groups revealed that different strategies were used. Group 2 consisted of two undergraduate students that had the least number of coded items (n=54) and they failed to arrive at a conclusion in the time given; however, Group 6 consisted of two postgraduate research students that had the highest number of coded items (n=219). This indicates that the implementation of decisions does not necessarily result in effective collaboration as Group 2 spent their in-world time focusing on navigation with large amounts of time between items and actions (Table 3), while Group 6 moved quickly through the world and established a pattern of deciding upon a goal state and implementing the goal.

The results also indicated that as Baker et al. (2001) found, participants did not express high levels of disagreement. Disagreement levels ranged between 0 – 2%, only Group 3 had a higher level of disagreement at 6% (n=6). However, when reviewing their patterns of disagreement, each disagreement was followed by an orientation process and led to further investigation (see Table 4). While disagreement may not be a pivotal factor in achieving a goal, confidence in expressing an opinion and in being part of a collaborative experience are factors that contribute to a successful collaborative learning experience.

Discussion

This study used a DFCS to analyze when, and if, participants converge on agreement of a course of action and when, and if, they implement their goal. The results of the study did show that all groups converged on goals and implemented desired activities, but that most of the goals focused on navigation rather than inquiry-based activities. This study was the third in a series of studies that examined the nature of the information and instruction required for participants to effectively interact with the given problem rather than focus on navigation around the space. Kleinermann, De Troyer, Creelle and Pellens (2007) noted the importance of navigation to enhance the usability of virtual environments (VEs), particularly in the context of the Web or for VEs reaching a large audience. To provide scaffolded navigation, Kleinermann et al. (2007) provided a tour guide and stored navigation paths that could be reused. However, we observed that not only were our participants “lost in cyberspace”, they also lacked a fundamental understanding of the domain and the nature of the problem. Our previous work which builds on human role playing games (Richards, 2006) found that “actors” must be appropriately primed to understand the context and immersed in the problem situation prior to entry into the game world. For example, in a training simulation in the border security domain using the first person shooter *Unreal Tournament* game engine, participants in our usability studies would often ask where their gun was so that they could shoot the passenger. To overcome this misunderstanding which interfered with successful engagement and learning in the training task we spent the first 15 minutes setting the scene and discussing with the participant what behaviors are normally exhibited by an immigration officer and what the role typically involved. Similarly, in *Virtual Singapore*, students also need sufficient background of the scenario

in order to be able to focus on the problem. To address this issue, in the next iteration of this study, scenes from a movie and several texts on cholera will be included in order for students to anchor their data collection to a tangible problem.

This study has also shown that groups that orient their processes and explore alternatives before implementing a goal tend to be more successful at collaboratively solving problems than groups that do not use similar strategies. This indicates that when using a MUVE, students should receive explicit scaffolding in how to make decisions as they engage in an activity and this instruction should be complementary to the instruction on how to navigate through the world. Furthermore, this scaffolding should include steps in decision making that involve disagreement.

Conclusions

Scenario-based MUVES may provide learners with a highly visual environment complete with interactive and authentic objects, but learners are not able to collaborate effectively to solve problems unless they have the prior instruction in how to use decision making strategies. Further to this, the results of this study suggest that students need to have prior knowledge of the scenario in order to be able to anchor their collaboration. This study has shown that while the participants did collaborate to achieve goals, the majority of the goals were focused on navigation rather than inquiry-based problem solving, which may indicate why learning outcomes in scenario-based MUVES are not as high as expected. Of course these findings are limited as this study involved a small sample size and a one-off interaction with the environment. The next iteration of this research study will involve priming the participants before the virtual activities and may provide a more detailed picture of collaborative problem solving in a scenario-based MUVE. Overall, collaborative skills and an understanding of the environment may equip students with sufficient background knowledge to enable deeper learning within the virtual environment.

References

- Banerjee, M. B., Capozzoli, M., McSweeney, L., & Sinha, D. (1999). Beyond Kappa: A Review of Interrater Agreement Measures. *The Canadian Journal of Statistics*, 27(1), 3-23.
- Barab, S. A., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making Learning Fun: Quest Atlantis, A Game Without Guns. *Educational Technology, Research and Development*, 53(1), 86 -107.
- Coulon, A. (1995). *Ethnomethodology* (J. C. a. J. Katz, Trans.). Thousand Oaks: Sage Publications.
- Dede, C., Clarke, J., Ketelhut, D. J., Nelson, B., & Bowman, C. (2005). *Fostering Motivation, Learning and Transfer in Multi-User Virtual Environments*. Paper presented at the American Educational Research Association. from <http://muve.gse.harvard.edu/rivercityproject/research-publications.htm#2005>.
- Kennedy-Clark, S. (2010). *Pre-service Teachers' Perspectives on using Scenario-Based MUVES in Science Education*. Paper presented at the Curriculum, Technology & Transformations for an Unknown Future. Ascilite 2010, Sydney, 497-507.
- Kleinermann, F., De Troyer, O., Creelle, C., & Pellens, B. (2007). *Adding Semantic Annotations, Navigation Paths and Tour Guides for Existing Virtual Environments*. Paper presented at the 13th International Conference on Virtual Systems & Multimedia, Brisbane, 50-62.
- Mazur, J. (2004). Conversation Analysis for Educational Technologists: Theoretical and Methodological issues for Researching the Structures, Processes and Meaning of On-line Talk. In D. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology*. New York: MacMillian.
- Mazur, J., & Lio, C. (2004). *Learner Articulation in an Immersive Visualization Environment*. Paper presented at the Conference on Human Factors in Computing Systems, Vienna, Austria.
- Poole, M. S., & Holmes, M. E. (1995). Decision Development in Computer/Assisted Group Decision Making. *Human Communication Research*, 22(1), 90-127.
- Reimann, P., Frerejean, J., & Thompson, K. (2009). *Using Process Mining to Identify Models of Group Decision Making in Chat Data*. Paper presented at the Computer Supported Collaborative Learning Practices, CSCL 2009, Rhodes, Greece.
- Richards, D. (2006). *Is Interactivity Actually Important?* Paper presented at the 3rd Australasian Conference on Interactive Entertainment (IE'2006) Murdoch University, Perth, 59-66.
- Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *The Journal of the Learning Sciences*, 2(3), 235-276.
- Sawyer, K. (2006). Analyzing Collaborative Discourse. In K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 187-204). Cambridge: Cambridge University Press.

Acknowledgments

The authors would like to acknowledge Singapore Learning Sciences Laboratory and Nanyang Technological University for their ongoing support in the use of *Virtual Singapura*.

Factors Contributing to Learners' Online Listening Behaviors in Online and Blended Courses

Alyssa Friend Wise, Jennifer Speer, Ying-Ting Hsiao, Farshid Marbouti
Simon Fraser University, 250-13450 102 Avenue, Surrey BC, Canada, V3T 0A3
Email: afw3@sfu.ca, jspeer@sfu.ca, yha73@sfu.ca, fmarbout@sfu.ca

Abstract: Much research on online discussions has focused on the messages contributed but not how learners interact with the existing discussion. These “online listening behaviors” are important to the learning process, influencing both the uptake of others’ ideas and the contributions made. Participants from two university courses (one blended, one fully online) were surveyed about factors influencing their online listening behaviors and their goal orientations. Results showed learners’ decisions about which posts to open were based on the reply structure (if a post replied to them or had many replies). Once opened, participants in the online class often used a “triage” strategy, scanning posts to decide if to read in more depth. In the blended class replying to posts that provoked a question was associated with a Mastery approach; replying to posts that agreed with the learner’s ideas was associated with Work-Avoidance. Implications for research and design of online discussions are presented.

Introduction

One of the key differentiators of online learning versus paper-based distance education is the opportunity to interact with others (Picciano, 2002). A common tool used to support online interaction is the asynchronous discussion forum. Theoretically, discussion forums can support students in actively engaging with others to negotiate meaning and build understanding (Boulos & Wheeler, 2007). The ability to support reflectivity in contributions (Harasim, 2001) and allow many voices to be heard (Shank & Cunningham, 1996), have also led to the use of discussion forums as part of face-to-face courses in a blended model. However, online discussions don’t always live up to their promise; in practice it is common to find fractured and incoherent conversations (Herring, 1999) with low levels of interactivity between students (Thomas, 2002).

The Importance of Online Listening Behaviors

How can we understand why conversations are occurring in this way? While a great deal of research has focused on the messages learners contribute (De Wever et al., 2006) and how they interact to produce group meaning-making (Arvaja, 2007), much less attention has been paid to the interactions learners have in the process leading up to these contributions. How learners navigate the existing discussion, which messages they choose to open, the strategies they use to interact with this content, and how they decide where to make their contributions are important parts of the knowledge construction process that influence both the contributions made and the uptake of ideas between learners (Suthers, 2006). In keeping with the idea of online discussions as conversations between learners, we refer to these actions collectively as “online listening behaviors” whose study can contribute to better understanding and design of online discussion interactions.

Initial work suggests that for many learners, their interactions with previous messages are brief and superficial. Thomas (2002) found that on average students read a low number of messages compared to the number they posted, and a substantial portion of messages did not meaningfully refer to previous ones. Hewitt (2003) found that while most students did read at least one message before composing their own, they took a “single-pass” strategy that focused almost exclusively on the most recently posted messages. In our own work (Wise et al., 2011), we have expanded these findings by using cluster analysis on log-file data to categorize specific learners as superficial, broad, or concentrated listeners based on the patterns of listening behaviors in which they engage. In this study we complement these mechanistic approaches by generating an understanding from the learner’s perspective of the factors they see affecting their online listening behaviors. Additionally, we examine the relationship between these factors and learners’ goals for participating in the online discussions to better understand how their choices may be driven by their achievement goals (Elliot & Murayama, 2008).

Research Questions

1. What factors do learners use in making decisions about their listening behaviors in asynchronous threaded discussion forums for online and blended courses?
2. Do these factors relate to learners’ orientation towards particular goals for participation?

Methods

Courses, Participants and Discussion Structure

Participants were students enrolled in two undergraduate courses at a mid-sized Canadian university. Discussion in both courses took place in Phorum, a basic asynchronous threaded discussion forum.

Business 200 was an undergraduate course on organizational behavior with two-hour weekly lecture and one-hour weekly tutorial. Students were also required to participate in three week-long (Sat-Fri) online discussions with half of their tutorial group (10-12 students) worth 9% of their grade. Students were asked to collectively solve an organizational behavior challenge and required to be “actively involved” in discussions, posting at least one comment per challenge. Demographics are shown in Table 1; less than a third of participants were native English speakers, which may not be representative of a typical western university classroom. The initial participant invitation was given in a face-to-face class which may account for the elevated response rate.

Education 299 was an undergraduate course on educational psychology taught fully online. Students were required to participate in six week-long (Mon-Fri) discussions in groups of 10 to 13 worth 20% of their grade. Discussions asked students to resolve an applied educational debate and required at least three posts on different days per discussion. The course is a prerequisite for the teacher preparation program and several Master’s level programs, thus often does not have a typical undergraduate population. As shown in Table 1, participants were mostly female, over 22, past the first two years of university and native English speakers. A large percent were also high achievers. Participants may not be representative of the class as a whole.

Table 1: Demographic information.

	Class Type	Participants / Class Size	Percent of participants who were:				
			Female	In 1 st 2 years of university	Older than 22	High achievers ('A' GPA)	Native English speakers
BUS 200	Blended	47 / 113	51%	85%	6%	11%	28%
EDUC 299	Online	20 / 95	80%	25%	55%	45%	90%

Questionnaire

Participants were invited to complete an online questionnaire at the end of their course. The questionnaire was developed to identify factors that learners perceive to influence their online listening behaviors. The questionnaire also probed learners past experiences and attitudes towards the course and discussion forums.

Online Listening Behaviors were measured by two 5-point Likert-style scales (“Not important at all”-“Extremely important”) that assessed what factors affected participants decisions about which posts to open (7 items) and reply to (12 items). An additional six 5-point items (“Never”-“Always”) asked participants about the frequency with which they used different strategies to interact with the posts once they were open. Item responses were examined individually.

Goal orientation refers to the kinds of objectives learners have for their participation in a learning activity. There are multiple dimensions of orientation, and a learner can rate high on more than one. Five-point Likert-style items (“Not at all true of me”-“Extremely true of me”) adapted from Elliot and Murayama’s (2008) Achievement Goal Questionnaire-Revised (AGQ-R) and Nesbit et al.’s (2009) Goal Orientation Questionnaire (GOQ) assessed orientation towards Mastery (learning as much as possible) [six items; $\alpha = .84$ (both classes)], Public Performance (appearing well in front of others) [four items; $\alpha = .80$ (BUS 200), $.91$ (EDUC 299)] and Work-Avoidance (doing the minimum necessary) [three items; $\alpha = .77$ (BUS 200), $.23$ (EDUC 299)]. The low reliability of the final scale is unexplained at this time; no further analyses were conducted for this data.

Participants’ Interest and Perceived Ability in the course materials were each assessed by four 6-point Likert items. Cronbach’s α was $.89$ (Interest – both classes), $.83$ (Ability - BUS 200) and $.87$ (Ability – EDUC 299). Perceived Value of the Discussion Forum was assessed by nine 6-point Likert items. Cronbach’s α was $.95$ (both classes). Participants’ Past Experience with Discussion Forums were measured by three 6-point items (“Never”-“Several times a day”) that assessed participants’ prior experience with the internet and discussion forums in general and two 4-point items (“Never”-“More than twice before”) that assessed participant’s prior experience using online discussion forums in academic contexts. One 6-point Likert-style item assessed participants’ comfort communicating in online discussions. Item responses were examined individually.

Results & Discussion

Past Experience with Discussion Forums

Participants’ reports of past experience with discussion forums are shown in Table 2. Both classes’ participants were frequent internet users. The majority of BUS 200 participants were also familiar with discussion forums in casual contexts; however, participants from EDUC 299 reported less familiarity with these. This may relate to differences in culture between business and education students, the ages of participants, or other demographic factors. Differences in experience with discussion forums in academic contexts were less pronounced. The majority of participants from both classes indicated that they were reasonably comfortable communicating

through online discussion forums. Few participants from either class had used the discussion forum tool used in this study before.

Table 2: Past experience with discussion forums.

% of participants who:	BUS 200	EDUC 299
Use the internet at least once a day	96%	95%
Read online discussion forums in casual contexts several times a week or more	70%	35%
Post in online discussion forums in casual contexts several times a week or more	43%	20%
Participated in an online discussion forum as part of a class at least once before	60%	40%
Were at least "somewhat comfortable" using discussion forums to communicate	64%	75%
Used Phorum discussion tool prior to this class	19%	10%

Interest and Ability in Materials, Value of Discussion Forum, and Goal Orientation

Participants' thoughts on the course and discussion forum and their goal orientations are shown in Table 3; splits were based on the midpoints of the scales. The great majority of participants in both classes reported being interested in the course materials and saw themselves as high performers. This may be related to the large proportion of participants who also reported a Mastery orientation. A Public Performance orientation was also prevalent, most notably in the BUS 200 class. Almost half of BUS 200 participants also displayed a Work-Avoidance Orientation. These differences may be due to variations in the age, culture, or other demographic factors between the groups. While almost three-quarters of BUS 200 participants valued the discussion forum as part of their course, only half of those in EDUC 299 did. This is surprising as we would predict that students in the fully online EDUC 299 would highly value the interactive aspect that discussions bring to online courses.

Table 3: Interest and ability in materials, value of discussion forum, and goal orientation.

	BUS 200	EDUC 299
Interest (% who were interested in the topics covered in this course)	85%	95%
Perceived Ability (% who saw self as high performer in course topic)	85%	95%
Value of Discussion Forum (% who valued it as a part of the course)	70%	50%
Mastery Orientation (% who tried to learn as much as possible)	77%	85%
Public Performance Orientation (% who tried to appear well in front of others)	89%	70%
Work Avoidance Orientation (% who tried to do the minimum necessary)	45%	-

Online Listening Behaviors

The factors participants reported as affecting their online listening behaviors are summarized in Table 4. In deciding which posts to open, participants in BUS 200 reported that factors related to the reply structure were the most important in influencing their choices: if a post replied to their own post or had a high number of replies, participants were inclined to open it. At a basic level this indicates that learners are in fact listening (and replying) to each other, contrasting Thomas's (2002) description of a majority of messages which were isolated and unrelated. Whether a post was new or made by someone they knew were also factors that affected BUS 200 students' decision to open a post; learners in Thomas's study also tended to read messages marked with "new" flags. Looking at relationships with goal orientation, there was a high correlation between both Mastery and Public Performance orientations for all of these factors except the number of replies. This factor was correlated with Public Performance and Word-Avoidance orientations, but not Mastery, suggesting that number of replies may not be a meaningful indicator of discussion quality. Work-Avoidance was also correlated with a location factor (top of the screen). Similar to the pattern seen for Mastery orientation in BUS 200, EDUC 299 participants reported that whether a post replied to one of their comments was an important factor they considered, but a high number of replies in general was not. Perhaps due to the high posting volume in the course (three comments per person per week minimum), EDUC 299 participants found both timing factors (new and recent) important to consider. Unlike the blended BUS 200 where students might know each other from the face-to-face class, participants in the fully online EDUC 299 did not report the author of a post as important.

The strategies used to interact with posts once open differed greatly between the classes. Participants in BUS 200 reported using all strategies equally, sometimes reading posts and sometimes scanning them. In contrast, participants in EDUC 299 exhibited greater selectivity in whether they chose to fully read a post, reporting frequent use of initial scanning to determine whether to continue reading. This may be due to several differences between the groups. First, EDUC 299 had a high posting volume compared to BUS 200 (three versus one minimum posts per week); thus, participants may have used these "triage" strategies to cope with an overwhelming number of posts. Second, EDUC 299 participants were generally older and higher-performing than those in BUS 200; it is possible that these strategies result from past successful use of other selective

approaches to studying. However, online discussions are different from other sorts of class-based reading in that they include responsive and interactive components that depend on what is read; thus it is possible that the inappropriate transfer of these strategies is one factor contributing to fractured and incoherent conversations. Looking at the relationships with goal orientation within BUS 200, no relationship between these strategies and a Mastery Orientation was observed. A Work-Avoidance orientation was correlated with these selective strategies, and also with the low effort strategies of only scanning or not reading posts. Further research is needed to determine if selective reading is in fact detrimental to conversational quality. If so, designers might promote more thorough reading through task design, process structure and smaller group sizes.

Table 4: Factors affecting participants' listening behaviors by class and correlations with goal orientation.

Behavior	Category	Factor	Mean(SD)		Goal Orientation Correlations for BUS 200		
			BUS 200	EDUC 299	Mastery	Public Perform	Work Avoid
Which Posts to Open	Reply Structure	Replied to one of my post	3.8 (1.1)	4.2 (1.1)	.47**	.65**	.09
		High # of replies	3.6 (1.0)	3.2 (1.3)	.16	.36*	.33*
	Author	Made by someone I know	3.3 (1.2)	2.7 (1.4)	.32*	.29*	.17
<i>Factor Importance</i> 5-pt scale	Timing	Marked as new	3.4 (1.2)	4.1 (1.1)	.42**	.42**	.02
		Made recently	3.0 (1.1)	4.0 (.70)	.19	.07	-.23
	Location	Near top of the screen	2.8 (1.2)	2.3 (1.4)	.15	.04	.38**
		Near bottom of the screen	2.3 (1.0)	1.8 (1.0)	.13	.08	-.04
How to Interact with Open Posts	General	Read thoroughly	3.6 (.85)	3.1 (.72)	.42**	.29	-.23
		Scan to get the main idea	3.6 (.91)	4.0 (.51)	.11	.07	.51**
		Scan to see if it was worth reading thoroughly	3.6 (1.1)	3.8 (.89)	.01	.00	.46**
<i>Frequency of Strategy Use</i> 5-pt scale	Long post	Didn't read	2.7 (1.0)	2.7 (.75)	.06	-.04	.41**
		Read a few lines to decide whether to read it	3.0 (1.1)	3.5 (.83)	.11	.11	.40**
		Read thoroughly anyway	3.1 (.80)	2.6 (.76)	.26	.11	-.27
Which Posts to Reply to	Content	Built on my ideas	3.8 (.86)	3.1 (.64)	.37*	.19	.23
		Agreed with my ideas	3.4 (1.0)	2.2 (.93)	.26	.15	.29*
		Provoked a question	3.3(1.0)	3.9 (.88)	.35*	.22	.19
		With which I disagreed	3.3(.90)	3.6 (1.1)	.25	.15	.19
<i>Factor Importance</i> 5-pt scale	Reply Structure	No other replies	2.5 (1.0)	1.8 (1.1)	.11	.04	.31*
		Made by someone I know	3.0 (1.1)	1.7 (1.0)	.31*	.13	.20
<i>Factor Importance</i> 5-pt scale	Author	Made a good student	2.8 (1.2)	2.0 (1.3)	.21	.04	.24
		Made recently	2.9 (1.1)	2.8 (1.3)	.18	.09	.36*
	Timing	One of the first posts read	2.6 (1.2)	1.8 (.97)	.29*	.09	.43**
		One of the last posts read	2.5 (1.1)	2.2 (1.1)	.11	-.11	.47**
	Location	First post in a long thread	2.7 (1.1)	2.1 (1.1)	.31*	.06	.09
	Last post in a long thread	2.5 (1.0)	2.2 (1.2)	.16	.01	.37*	

* p < .05 ** p < .01

The decision about where to post a reply to the conversation drew on several factors. For both groups, the recentness of a post was found to be a somewhat important, aligning with previous work showing that recent posts are more likely to get responses (Hewitt, 2003). More interestingly, participants in both courses indicated that factors related to the content of posts were the most important in deciding where to reply. Within the content category, different foci were seen for the two groups. Participants in BUS 200 placed the most importance on replying to posts that built on their ideas, whereas participants in EDUC 299 put more emphasis on replying to posts that provoked questions or with which they disagreed. In Gunawardena et al.'s (1997) models of Knowledge Construction, the BUS 200 pattern aligns with Phase 1 (Sharing Ideas) while the EDUC 299 pattern aligns with Phase 2 (Exploring Dissonance). This suggests that the EDUC 299 participants are engaging in listening behaviors related to a higher phase of knowledge construction, perhaps due to a task structure that specifically asked them to resolve a debate or their status as older, high achieving learners. Looking at the relationships with goal orientation within BUS 200, a Mastery orientation was associated with replying to posts which provoked a question and those which built on the learner's ideas, while a Work-Avoidance orientation was associated with replying to posts that agreed with the learner's ideas. It seems that structuring discussions to encourage disagreements and questioning rather than simply agreement may be a goal worth pursuing. A Work-Avoidance orientation was also associated with several timing and location factors.

Conclusion

Very little work has looked at the interactions learners have with online discussion forums in the process leading up to their contributions. These online listening behaviors are important parts of the knowledge construction process that influence both the contributions made and the uptake of ideas between learners. This study generated an initial understanding of factors learners see affecting their online listening behaviors and their relationship with different kinds of achievement goals. Future work can build on this study by evaluating the relationship of these behaviors to educationally desirable processes to determine which behaviors should be encouraged versus discouraged. This study found that learners' decisions about which posts to open rely most strongly on factors related to the reply structure and that the "number of replies" factor was related to Public Performance and Work-Avoidance orientations. In interacting with the posts once opened, EDUC 299 participants often used a triage strategy, scanning posts and deciding if to read in more depth. In the BUS 200 class, these strategies were associated with a Work-Avoidance orientation. In conducting this work, the researchers noticed that there are few cues to guide learners in choosing which posts to interact with. Many of these are superficial (e.g. "new" post flags) and have been critiqued in previous work (Hewitt, 2003). Faced with a large number of posts and little selection guidance, it is not surprising that learners use a triage strategy. Future work is needed to determine if this is efficient or detrimental and explore what more meaningful cues for choosing posts can be provided by the system or generated by the learners (e.g. topical tags, reputation systems). Findings about what factors influence where learners choose to make a reply emphasized the content of posts. EDUC 299 participants placed importance on if a post provoked questions or disagreement; exhibiting listening behaviors possible related to Phase 2 of knowledge construction (Gunawardena et al., 1997). In BUS 200 replying to posts that provoked a question was associated with a Mastery orientation while replying to posts that agreed with the learner's ideas was associated with Work-Avoidance. Future work can test this relationship in more complex scenarios and situations, and explore ways to structure discussions that encourage disagreements and questioning through group composition, task structure, and other scripting factors such as assigned roles.

References

- Arvaja, M. (2007). Contextual perspective in analysing collaborative knowledge construction of two small groups in web-based discussion. *International Journal of Computer-Supported Collaborative Learning*, 2(2-3), 133-158.
- Boulos, M. N., & Wheeler. S. (2007). The emerging web 2.0 social software: An enabling suite of sociable technologies in health and health care education. *Health Information and Libraries Journal*, 24, 2-23.
- De Wever, B., Schellens, T., Valcke, M., & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education*, 46(1), 6-28.
- Elliot, A., & Murayama, K. (2008). On the measurement of achievement goals: Critique, illustration, and application. *Journal of Educational Psychology*, 100, 613-628.
- Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research*, 17(4), 397-431.
- Harasim, L. (1987). Teaching and learning on-line: Issues in computer-mediated graduate courses. *Canadian Journal of Educational Communication*, 16 (2), 117-135.
- Herring, S. (1999). Interactional coherence in CMC. *Journal of Computer-Mediated Communication*, 4(4).
- Hewitt, J. (2003). How habitual online practices affect the development of asynchronous discussion threads. *Journal Educational Computing Research*, 28(1), 31-45.
- Nesbit, J. C., Zhou, M., Mahasneh, R., & Yeung, P. (2009). The *Goal Orientation Questionnaire (GOQ)*. Simon Fraser University. Available at <http://www.sfu.ca/~jcnnesbit/EDUC220/StratRef/GOQ.htm>
- Picciano, A. G. (2002). Beyond student perceptions: Issues of interaction, presence, and performance in an online course. *Journal for Asynchronous Learning Networks*, 6(1), 21-40.
- Shank, G., & Cunningham, D. (1996). Mediated phosphor dots: Toward a post-cartesian model of CMC via the semiotic superhighway. In Ess, C. (Ed.), *Philosophical perspectives on computer-mediated communication*. Albany, NY: State University of New York Press.
- Suthers, D. (2006) Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 315-337.
- Thomas, M. J. W. (2002). Learning within incoherent structures: the space of online discussion forums. *Journal of Computer Assisted Learning*, 18, 351-366.
- Wise, A. F., Speer, J. A., Marbouti, F., & Hsiao, Y. (2011). Towards an understanding of "listening" in online discussions: A cluster analysis of learners' interaction patterns. *Proceedings of the International Conference on Computer Supported Collaborative Learning*, Hong Kong, China.

Acknowledgments

This work was supported by the Social Sciences and Humanities Council of Canada.

Supporting Argumentative Knowledge Construction in Face-to-Face Settings: From ArgueTable to ArgueWall

Sara Streng, Media Informatics, University of Munich, Amalienstrasse 17, 80333 Munich, Germany
Karsten Stegmann, Department Psychology, University of Munich, Leopoldstrasse 13, 80802 Munich, Germany
Christine Wagner, Media Informatics, University of Munich, Amalienstrasse 17, 80333 Munich, Germany
Sonja Böhm, Media Informatics, University of Munich, Amalienstrasse 17, 80333 Munich, Germany
Frank Fischer, Department Psychology, University of Munich, Leopoldstrasse 13, 80802 Munich, Germany
Heinrich Hussmann, Media Informatics, University of Munich, Amalienstrasse 17, 80333 Munich, Germany
Email: sara.streng@ifi.lmu.de, karsten.stegmann@psy.lmu.de, wagnerchr@cip.ifi.lmu.de, sonja_v_b@yahoo.com, frank.fischer@psy.lmu.de, heinrich.hussmann@ifi.lmu.de

Abstract: Research on computer-supported collaboration scripts has so far widely neglected human-computer-interaction (HCI) aspects. This paper presents a set of case studies on the user interface of a computer application that smoothly fits into the practice of argumentative knowledge construction in co-located collaborative learning. During an iterative design process different user interface designs were evaluated regarding their effects on the knowledge construction process. Starting from a tabletop application ('ArgueTable') the design process led to an alternative display environment ('ArgueWall'), which uses laptops together with a shared wall display. The results show that HCI aspects can have strong effects on the scripted learning processes. Due to the inherent interaction of humans and computers, HCI should be an integral part of research on computer-supported collaborative learning (CSSL).

The Need for Computer Support in Argumentative Knowledge Construction

While high quality of argumentation has shown to be beneficial for learning, it is rarely found in unsupported collaboration (cf. Kollar, Fischer & Slotta, 2007). Learners usually do not provide grounds and qualifications for their claims. In addition, learners rarely raise socio-cognitive conflicts through counter argumentations. A possible solution is to provide instructional means that focus on the quality of argumentation to enhance collaborative learning. Computer-supported collaboration scripts have been successfully implemented to facilitate collaborative knowledge construction by increasing the quality of argumentation during discussions (e.g. Stegmann et al., 2007).

However, research on collaboration scripts has widely neglected an important aspect that plays a role in computer-supported collaborative learning: variations of the user interface as studied in HCI. Collaboration scripts are often implemented using typical desktop user interface elements, such as textboxes, buttons and drop-down menus. Such interfaces often do not reach the goal of providing an intuitive interface, which guides learners naturally through the process. Instead, text-based instructions are commonly used, leading to a waste of time and a misplaced emphasis on the task of operating the computer.

This paper presents studies on the user interface design of a computer application for argumentative knowledge construction in face-to-face collaborative learning. The user interfaces were developed using an iterative design process as proposed by Nielsen (1993). The studies show that the design of the user interface - in particular the choice of displays - can have strong effects on script-based learning processes.

HCI in the Design of Applications for Collaborative Learning

In the field of HCI a number of studies have shown that the type of display environment can affect co-located collaborative processes. Some of the display characteristics that play a role are the number, orientation, size and privacy of a display as well as the seating arrangement and the users' proximity to the display (Mandryk, Scott & Inkpen, 2002).

Several of these aspects also play an important role in collaborative *learning* scenarios. First, depending on the number, size and orientation of displays, they can offer *private* workspaces or be visible to the whole group, which increases the *awareness* of the learning partner's activities (Mandryk, Scott & Inkpen, 2002). An increased awareness could have positive effects (e.g. efficient task coordination) as well as negative effects (e.g. distraction from the primary task). Second, the *balance of participation and role distribution* within the team can be affected. For instance, Rogers and Lindley (2004) found collaboration to be more balanced on horizontal displays compared to vertical ones. Furthermore, empirical studies indicate that combinations of shared and *private* workspaces can support a more equal participation in face-to-face collaborations (Looi et al., 2008). Third, there are ergonomic aspects such as arm fatigue or limited elbowroom (Inkpen et al. 2005). The result of such factors combined is that different types of displays are used for different purposes (cf. Everitt et al., 2006) and thus have different *affordances*.

Computer-Support for Argumentation

Scheuer and colleagues (2010) have done an extensive literature review on systems that support argumentation. They identified different types of argument representations that have been used in such systems: linear, threaded, graph-based, container and matrix. Empirical studies show that the type of argument representation can affect collaboration. Suthers and colleagues (2008) conducted a study in which they found that knowledge maps better facilitate collaboration as compared to threaded discussions. Furthermore, Lund and colleagues (2007) compared different ways of using argumentation diagrams: as a means for debate or as representation of the debate. In their study, instructions on how to use the argumentation diagram had a significant effect on the argumentation itself. A further important aspect is the concrete task at hand, for instance whether to focus on the individual or group performance (cf. Pfister and Oehl, 2009).

Iterative Design Process

Against this background, our goal was to create an application, which guides learners during the creation of arguments. According to Toulmin (1958) these arguments should consist of claim, grounds and qualification. Furthermore, we aimed at facilitating argument sequencing (cf. Leitão, 2000).

To develop an optimized user interface, we followed an iterative design process as proposed by Nielsen (1993). During this design process the user interface is iteratively tested by users (in our case learners) and then refined according to their feedback. That way, usability problems can be identified early in the design process and the user interface is gradually improved.

Paper Prototype Study

Due to the findings in the field of HCI discussed above, we chose a tabletop displays for our learning scenario. In particular, we were interested in two characteristics that tabletop displays facilitate: (1) they foster balanced participation rates (Rogers and Lindley, 2004) and (2) they enable natural face-to-face communication, e.g. in terms of eye contact (Inkpen et al., 2005). In the beginning of our iterative design process, we therefore created a paper prototype of a tabletop system, in which learners are seated on opposite sides of a table.

We started with the question how argument representations should look like in order to be comprehensible and at the same time support learners in creating arguments. To examine this question, different stacks of cardboards were provided to the participants. Each cardboard represented an argument. There were different types of argument representations: (1) A triangular design with the captions 'claim', 'grounds' and 'qualification', (2) a linear design with the clause openers 'I think that', 'because' and 'unless' and (3) an empty cardboard that allowed learners to create own designs for argument representations. The cardboards were placed on a table, which was covered with a table-sized piece of paper. Arguments could be sequenced by drawing lines on the paper background. In addition, flexible wires could be attached to cardboards.

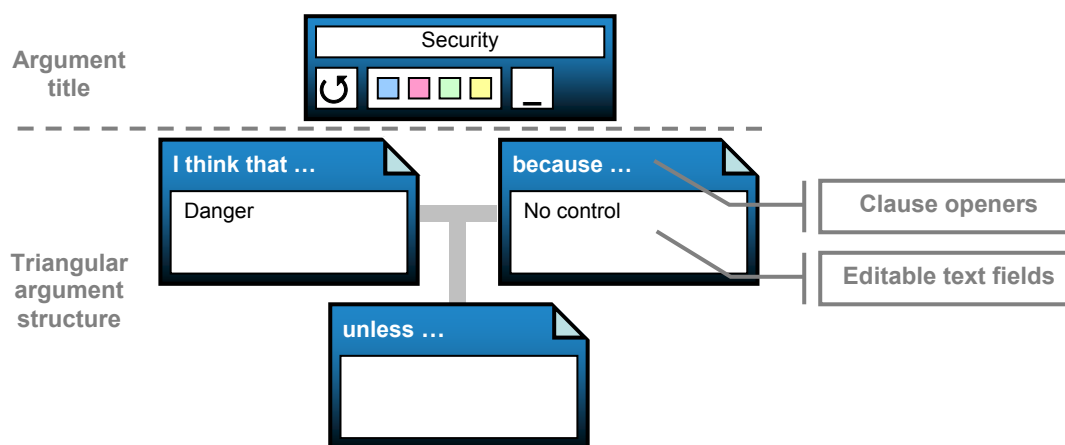


Figure 1. Redesign of Argument Representations after the Paper Prototype Study.

Overall, N=12 learners in groups of two or three participated in the paper prototype study. 58% were female. Four of them were graduate students, the remaining eight were doctoral students. Participants were asked to imagine they took a course called "Learning how to argue". In the beginning a short introduction was given, in which the structure of arguments was explained. Learners were instructed to create arguments consisting of claim, grounds and qualification, to provide pros and cons, to build argument sequences by relating their arguments to their learning partner's arguments, and finally to draw a conclusion. The participants were told that in the end the content of the table should represent the course of discussion. There was no time limit to ensure that all groups would be able to reach a conclusion. After the groups had finished their

argumentation there was an open discussion, which the experimenter started by asking why the according design alternatives were chosen. Later, more general feedback was collected and finally the participants were asked to modify or create their own designs. The feedback of the participants led us to a redesign of the interface for the construction of single arguments (see Figure 1). Furthermore, we identified argument sequencing as difficult task, which is rarely done by learners even when instructed to do so.

Comparing Two Display Environments: ArgueTable or ArgueWall?

Based on the lessons learned in the paper prototype study, a functional tabletop prototype was implemented and gradually refined. For this purpose several case studies were conducted, using the same task and proceeding as in the paper prototype study described above. While several issues were improved, the deficient argument sequencing remained despite several measures (e.g. specific metaphors that indicate which arguments should be linked). Across all studies, we observed that learners mainly interacted with the application in the first phase when argument representations were built. During the subsequent discussion, in which the task was to build argument sequences, there was little interaction with the application. These observations led us to the hypothesis that using separate displays for the two phases could emphasize that there is still further interaction needed in the second phase. We therefore started to think about separate physical workspaces for the two learning phases. This made us question the reasons for choosing a tabletop scenario in the first place.

Thus, we conducted a final study in which the tabletop application ('ArgueTable') was compared to a distributed application consisting of laptops and an interactive wall ('ArgueWall'). We decided to use a wall-mounted display instead of a tabletop display as shared workspace, because the combination of laptops and a tabletop display did not seem feasible. For instance, as occlusion has to be avoided, it would not be clear where the laptops should be placed. Hinrichs et al. (2007) describe how even much smaller devices such as hardware keyboards can create a barrier between user and tabletop or make interaction clumsy if the keyboard is removed and retrieved when needed.

Research Questions

Against this background, we examined two research questions:

RQ1: To what extent does the display setting (ArgueTable vs. ArgueWall) affect processes during argument preparation? We expected the awareness of the learning partner's activities to be higher on the ArgueTable compared to the ArgueWall condition (where the individual work takes place in private workspaces). At the same time, we expected the individual work to be less disturbed in the ArgueWall condition, because there is less distraction by the learning partner's activities.

RQ2: To what extent does the display setting (ArgueTable vs. ArgueWall) affect collaborative argumentation? We expected more argument sequences in the ArgueWall condition. Furthermore, we were aware of the possibility that only one of the two learners stands up and interacts with the wall display. This could lead to unwanted role distributions, such as thinker and writer.

Methods

Participants and Design. Ten dyads (N=20) participated in our study. 45% participants were female. Their age ranged from 20 to 31 (M=24.85, SD=3.63). We varied the type of display setting using a within-subject design. Therefore, all participants used both types of display setting in a counterbalanced order.

In the ArgueTable condition a tabletop display was used for both, the individual and collaborative phase. During the individual phase, the workspace was graphically divided into two personal workspaces. During the collaborative phase, the same tabletop display served as shared workspace.

The ArgueWall condition was realized using two laptops during the individual phase. Participants created their argument representations next to each other using laptops, but without direct sight on the learning partner's display. During the collaborative phase a wall mounted display was used. The individually created arguments could be transferred to the shared display using the Gateway interaction technique (cf. Guinard et al, 2007). To create argument sequences, users had to stand up and move and/or connect their arguments on the wall-mounted display using direct touch.

Learning Task and Procedure. At the beginning, the functionalities of the applications were demonstrated by creating exemplary arguments on the topic 'ban on smoking in restaurants'. The functionalities of both applications during the individual and collaborative phase were identical: By dragging notes from a stack, new argument representations can be created, each consisting of the three components claim, grounds and qualification (on laptops or on the tabletop display). In the collaborative phase, argument representations can be freely arranged using direct touch dragging gestures on the shared, interactive (wall-mounted or tabletop) display. Furthermore, argument notes can be linked in order to build argument sequences. It is also possible to minimize single arguments as well as entire argument sequences. After the introduction, participants were asked to discuss two different topics: 'pro/con tuition fees' and 'pro/con speed limits on highways'. For each topic

learners should first prepare three important arguments that support their position (pro or con) before discussing the topic.

Data sources and Dependent variables. After each discussion a questionnaire with items regarding the previous discussion was administered. The subjective awareness of the learning partner's progress, the subjective distraction from the learning task and the subjective confrontation during the collaborative argumentation were measured with a self-report questionnaire. All items had to be answered on a 5-point Likert scale from 1 ('completely disagree') to 5 ('completely agree'). *Awareness* was measured with the item 'It was easy to detect when my partner was finished with preparing arguments'. *Distraction* was measured with the item 'I could prepare my arguments undisturbed'. *Confrontation* was measured with the item 'In the discussion I perceived my learning partner as opponent'. Furthermore, the number of argument sequences was used as indicator for the *quality of argument discourse* (cf. Stegmann et al., 2007). In order to examine the *role distribution* within the dyad, the participants were not instructed regarding different roles during the discussion.

Statistical tests. All inference statistical tests were performed against a 5% error level. Paired-sample t-tests were performed according to the type of dependent variable at hand.

Results

RQ1: Effects of display setting (ArgueTable vs. ArgueWall) on processes during argument preparation:

Awareness. Regarding the perceived awareness, the mean answer was higher for the ArgueTable ($M = 3.85$, $SD = 1.23$) than for the ArgueWall condition ($M = 2.85$, $SD = 1.57$). A paired-sample t-test showed a significant effect, $t(19) = 2.30$, $p = .03$, two-tailed, $r = .47$, $d = .72$. However, the questionnaire results also indicate that the awareness was not considered to be an important factor for the choice of display environment.

Distraction. To assess the subjective distraction, the answers of the item 'I could prepare my arguments undisturbed' were reversed. Using the ArgueTable participants felt more distracted ($M = 1.35$, $SD = 0.93$) than in the ArgueWall condition ($M = 2.05$, $SD = 1.19$). A paired-sample t-test showed a significant effect, $t(19) = -2.33$, $p = .03$, two-tailed, $r = .47$, $d = -.66$.

RQ2: Effects of display setting (ArgueTable vs. ArgueWall) on collaborative argumentation:

Argumentative discourse quality. The mean number of argument sequences built on the ArgueTable was lower ($M = 2.41$, $SD = 1.51$) compared to the ArgueWall ($M = 4.20$, $SD = 2.25$). A paired-sample t-test showed a significant effect, $t(9) = -2.59$, $p = .029$, two-tailed, $r = .65$, $d = -.96$.

Confrontation. Regarding the item 'In the discussion I perceived my learning partner as opponent', the mean answer was $M = 3.35$ ($SD = 1.39$) for the ArgueTable and $M = 3.90$ ($SD = 0.91$) for the ArgueWall condition. A paired-sample t-test showed a significant effect, $t(19) = -2.34$, $p = .030$, two-tailed, $r = .47$, $d = -.48$. Thus, the partner was perceived more as opponent in the ArgueWall condition and less so in the ArgueTable condition.

Role distribution. In the ArgueWall condition, both learners stood up at the beginning of the collaborative phase and engaged in the discussion across all dyads. Therefore, an unwanted role distribution (such as one person being responsible for the interaction with the application, the other one for contributions with regards to content) was not observed.

Discussion

The need to switch displays between individual and collaborative phases (as in the ArgueWall setting) seemed to increase the concentration on the discussion phase and its associated tasks. Regarding the question of confrontation, the answers showed that the learning partner was less perceived as opponent in the tabletop condition, i.e. when sitting face-to-face. Previous studies, which compared face-to-face and side-by-side seating arrangements (cf. Sommer, 1967), suggested the opposite. A possible explanation for this discrepancy was found in informal interviews conducted at the end of the user study. According to participants' statements, working on separate displays during the individual phase triggers the notion of self-dependency. It seems whether one is working on a shared or separate displays has a larger effect on the subjective confrontation than the seating arrangement. Finally, a role distribution within the dyad could not be detected. In all groups both learners went to the wall-mounted display and interacted with the application. Their part in the discussion was fairly balanced. These observations were confirmed by questionnaire results, which pointed out that the participants had the feeling of an equal distribution of work. Again, this finding differs from related work, which found collaboration to be less balanced around wall displays (cf. Rogers & Lindley, 2004). Our assumption is that in our study both learners felt equally responsible for the interaction on the wall display, as they both created part of the content in the prior individual phase.

In summary, the final study revealed clear advantages of an explicit private workspace for individual phases in collaborative learning scenarios. This aspect was considered more important than the awareness of the learning partner's progress. Moreover, the number of argument sequences was much higher on the ArgueWall, which can be ascribed to both a more clearly arranged workspace and increased concentration due to the display switch between the individual and collaborative phase.

Conclusion

When developing computer applications to support collaborative learning scenarios, the design of the user interface plays an important role. In co-located settings a major factor is the choice of display environment for individual as well as collaborative tasks. Several studies have shown that different types of displays have various assets and drawbacks (e.g. Inkpen et al., 2005). However, it is hard to foresee how important the individual pros and cons of a certain display environment are in a specific collaborative scenario, which makes the choice very difficult. In our case, the iterative design process led to a display environment that looked very different from our first vision, which was derived from findings in related work (ArgueTable). The final display setting, consisting of laptops and an interactive wall display (ArgueWall), showed to have significant positive effects on the collaborative learning process. We therefore recommend that for new collaboration-supporting systems the design process starts from the basis of relevant related work, but also takes into account a broad range of possible hardware configurations and includes low-cost comparative evaluations. Small case-studies with low- and high-fidelity prototypes appear to be superior to *only* applying rather general guidelines from the literature when it comes to finding adequate designs.

Our findings underline that research on the user interface should be an integral part of CSCL. Our studies showed that HCI aspects can have strong effects on script-based learning processes. These effects may interact positively or negatively with scaffolds like collaboration scripts. Our recommendation is to develop scaffolds for CSCL in an iterative design process, before studying effects of these scaffolds on collaborative learning in traditional experiments.

References

- Everitt, K., Shen, C., Ryall, K., & Forlines, C. (2006). Multispace: Enabling electronic document micro-mobility in table-centric, multi-device environments. In *Proceedings of TABLETOP '06*, Washington, DC, USA. IEEE Computer Society, 27–34.
- Guinard, Dominique and Streng, Sara and Gellersen, Hans (2007) Extending Mobile Devices with Spatially Arranged Gateways to Pervasive Services. In: *International Workshop on Pervasive Mobile Interaction Devices (PERMID 2007)* at the International Conference on Pervasive Computing, 2007.
- Hinrichs, U., Hancock, M., Collins, C., & Carpendale, S. (2007). Examination of Text-Entry Methods for Tabletop Displays. *Proceedings of the Horizontal Interactive Human-Computer Systems (TABLETOP) 2007*, 105-112
- Inkpen, K., Hawkey, K., Kellar, M., Mandryk, R., Parker, J., Reilly D., Scott, S.D., & Whalen, T. (2005). Exploring display factors that influence co-located collaboration: Angle, size, number, and user arrangement. *Proceedings of HCI International 2005*.
- Kollar, I., Fischer, F., & Slotta, J. D. (2007). Internal and external scripts in computer-supported collaborative inquiry learning. *Learning & Instruction*, 17(6), 708-721.
- Leitão, S. (2000). The potential of argument in knowledge building. *Human Development*, 43, 332-360.
- Looi, C.-K., Lin, C.-P., Liu, K.-P., July 2008. Group scribbles to support knowledge building in jigsaw method. *IEEE Transactions of Learning Technologies 1(3)*, 157-164.
- Lund, K., Molinari, G., Séjourné, A., Baker, M., 2007. How do argumentation diagrams compare when student pairs use them as a means for debate or as a tool for representing debate? *International Journal of Computer-Supported Collaborative Learning 2*, 273-295.
- Mandryk, R.L., Scott, S.D. & Inkpen, K. (2002). Display Factors Influencing Co-located Collaboration. In *Conference Supplement to ACM CSCW'02*. ACM.
- Nielsen, J. (1993). *Iterative User Interface Design*. IEEE Computer 26(11), 32-41.
- Pfister, H. R., & Oehl, M. (2009). The impact of goal focus, task type and group size on synchronous net-based collaborative learning discourses. *Journal of Computer Assisted Learning*, 25(2), 161-176.
- Rogers, Y. & Lindley, S. (2004). Collaborating Around Vertical and Horizontal Large Interactive Displays: Which Way is Best? In *Interacting with Computers 16(6)*, 1133-1152.
- Scheuer, O., Loll, F., Pinkwart, N., McLaren, B., 2010. Computer-supported argumentation: A review of the state of the art. *International Journal of Computer-Supported Collaborative Learning 5*, 43-102.
- Sommer, R. (1967). *Small group ecology*. Psychological Bulletin, 67 (2), 145-152.
- Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*, 2(4), 421-447.
- Suthers, D. D., Vatrappu, R., Medina, R., Joseph, S., Dwyer, N., 2008. Beyond threaded discussion: Representational guidance in asynchronous collaborative learning environments. *Computers Education 50 (4)*, 1103 - 1127.
- Toulmin, S. (1958). *The uses of argument*. Cambridge: Cambridge University Press.

Coding Schemes as Measurement Instruments? An Attempt to Assess the Psychometric Properties of a Coding Scheme

Andri Ioannou, Cyprus University of Technology, P.O. Box 50239, Limassol 3603, Cyprus,
andri.ioannou@gmail.com

Agni Georgiou, Elena Papanastasiou, University of Nicosia, P.O. Box 24005, Nicosia 1700, Cyprus,
Email: stylianou.a@unic.ac.cy, papanastasiou.e@unic.ac.cy

Abstract: CSCL researchers rely heavily on coding schemes to analyze collaborative discourse. As Rourke and Anderson (2004) explain, examples of qualitative content analysis (QCA) research in which a coding scheme is developed methodically and validated systematically are rare. In this study, we attempted to conduct a validation of a coding scheme using established quantitative methods; this was an effort to foster the replicability and validity of a coding scheme designed to measure online collaborative learning. Exploratory Factor Analysis suggested a different factor structure than the one conceptualized in the coding scheme. The authors raise questions related to what are the most appropriate and acceptable procedures in establishing the validity of coding schemes used in QCA.

Purpose of the Study

CSCL researchers place great emphasis on analyzing discourse (verbal data) -- and the collaborative learning processes captured in it -- in order to understand learning in groups (i.e., Dillenbourg, Baker, Nlaye, & O'Malley, 1996; Hmelo-Silver, 2003; Stahl, 2006). As Dillenbourg et al. (1996) stated, "deciding on the meaning of these expressions in a given dialogue context is quite complex, but necessary if we are to understand when students are really collaborating and co-constructing problem solutions" (p.18).

QCA is widely used as a methodology for the analysis of collaborative discourse, including discourse of asynchronous, computer-mediated discussion groups. The approach generally assumes the researcher will operationalize and unambiguously define the key themes (phenomena) to be coded, create coding categories, and establish their reliability by getting multiple raters to agree on how the categories should be applied to a sample of the data (see Chi 1997 for a detailed description of the steps involved in the creation of a coding scheme for QCA). Despite the large number of CSCL studies using QCA, the methodology has yet to achieve scientific status. Major critiques are concerned with the accuracy, objectivity, reliability, replicability, and validity of the coding schemes, as discussed in the review by De Wever, Schellens, Valcke, & Van Keer (2005). Rourke and Anderson (2004) also pointed out that examples of QCA research in which a coding scheme is developed methodically and validated systematically are rare.

Our goal in this study was to foster the replicability and validity of a coding scheme designed to measure online collaborative learning, so that future studies could further benefit from using it for QCA. We followed a 2-step approach: First, we adapted an existing instrument developed and applied in previous research. Then, after coding and counting of a large dataset, we employed established methods in quantitative research to examine the psychometric properties of the coding scheme. In other words, we treated a (qualitative) coding scheme as a (quantitative) measurement instrument. Exploratory Factor Analysis (EFA) followed by Reliability Analysis were used to examine whether the variety of themes (sub-categories) found in the online collaborative discourse could be reduced to invariant structures (factors) that matched the conceptualized categories in the coding scheme.

Method

The Coding Scheme

Researchers, such as Rourke and Anderson (2004) and De Wever et al. (2005) strongly encourage the re-use of coding schemes developed in previous research to foster their replicability and validity. Thus, the coding scheme for the study was adapted from Hmelo-Silver and Chernobilsky (2004). This scheme was developed using Activity Theory (e.g., Engeström & Miettinen, 1999) as the theoretical lens for understanding CSCL. Then, it was used for the study of collaborative learning during problem-based activities in the eSTEP and STELLAR environments (see Hmelo-Silver and associates).

The coding scheme was piloted with discourse data from 19 graduate students, in an Educational Psychology course, who collaborated online for the analysis of a case study with ultimate goal to co-construct a solution to the problem embedded in the case. During the piloting of the coding scheme, two content experts refined its operationalization using 10% of the data. The unit of analysis (segment) was determined to be a consistent "unit of meaning"; each theme was classified into a different coding category, as a separate unit of analysis. Segmentation and coding were carried out together (i.e., in one parse of the discourse). Using the

refined coding scheme, the two coders coded the whole discourse independently with an acceptable inter-rater agreement (Ioannou, Bushey, & Artino, 2009). The coding scheme includes four main discourse categories (knowledge sharing, student collaboration, planning, and other content), broken into 17 subcategories, as presented in Table 1. Examples of the codes for each subcategory are omitted due to space limitation, but can be provided upon request.

Table 1: Coding scheme.

Category/ Factor	Sub-category/ Variable	Operationalization
1. Knowledge Sharing	1.Telling	This contribution corresponds to a discussion of facts, concepts, theories, and experiences with little or no clear connection to the case or earlier ideas contributed to the discussion.
	2.Elaborated Telling	This contribution corresponds to a discussion of facts, concepts, theories, and experiences in relation to earlier ideas contributed to the discussion and with clear connection to the case.
	3.Transforming	This contribution corresponds to a <i>critical</i> discussion of facts, concepts, theories, and experiences in relation to earlier ideas contributed to the discussion and with clear connection to the case; this discussion reflects argumentation and reasoning, beyond simple elaboration.
2. Student Collaboration	4.New Ideas	Learner presents an idea or opinion that is new in the context of the discussion. Includes ideas about defining the problem and identifying a solution.
	5.Modification	Learner only partially agrees with a presented idea or opinion, but makes a modification to it.
	6.Elaboration/ Expansion	Learner presents statements, clues, or comments that further refine or expand an earlier idea/opinion; this contribution does not include a critical discussion of concepts and theory to make this complex.
	7.Agreement/ Consensus	Learner presents statements of agreement between and amongst group members.
	8.Disagreement	Learner presents statements of disagreement between and amongst group members.
	9.Syntheses/ Summaries	Learner presents summary previous ideas; this contribution does not include a critical discussion to make this statement complex.
	10.Acknowledgment	Acknowledgment of a contribution.
	11.Explanatory Questions	Asking for clarification or justification of some idea or opinion.
	12.Meta and Prompts	Questions, comments, or suggestions that prompt further discussion and meta-thinking; these statements are idea-oriented, rather than task-oriented.
13.Justification/ Clarification	Elaboration, justification, clarification as a result of an elaborative question.	
3. Planning	14.Monitoring and Planning	Includes self-monitoring and group-monitoring utterances and decisions about how to move forward with the task.
4. Other Content	15.Tool-related talk	Questions, answers, comments, and clarifications related to the technology.
	16.Process-related talk	Questions, answers, comments, and clarifications related to the task or process.
	17.Social Talk	Talk amongst group members that does not add directly to the task.

Data Collection and Procedure

In a subsequent larger scale-study, data were collected from 175 graduate students, working in groups of 3-4 members. The data were collected over a period of two years, in sections of two different courses (Learning Theory and Educational Psychology), in two different universities (a public University in the Northeast USA and a private University in Cyprus), while students collaborated on the same online case study activity.

The coding scheme of Table 1 was used to analyze the online discourse of all groups. Like with the pilot, the unit of analysis was the "unit of meaning" and segmentation and coding were carried out together. Two coders coded approximately 50% of the discourse independently, with an acceptable inter-rater agreement

(close to 80%). Disagreements were resolved with discussion between the coders until 100% agreement was achieved. Then, one of the coders finished coding the rest of the discourse. A total of 3385 units were coded (i.e., $N=175$ graduate students \times n° units of analysis = total # of units coded).

Analysis and Results

Following the coding and counting in QCA, the data were organized into an SPSS file -- the 17 variables (sub-categories) were organized through the 175 subjects. An EFA was carried out to examine whether the variety of themes (variables) found in the online collaborative discourse could be reduced to invariant structures (factors) that matched the conceptualized categories in the coding scheme. Ideally, the factor structure of the data would match the main categories of the coding scheme of Table 1. The oblique, Promax rotation with Kaiser Normalization was used to allow the factors to be correlated with each other. In addition, the Maximum Likelihood extraction method was used; this is a true factor analysis extraction method that analyzes only the common variance in the variables and produces optimal results that reflect the nature of the population (Costello & Osborne, 2005). Finally, the eigenvalues cut-off point was set to 1.1 to ease in the interpretation of the factors. Four factors were extracted that accounted for 61.27% of the total variance in the data. The first factor explained 27.19% of the variance and included 6 variables (7, 4, 3, 2, 6, 10). The second factor explained 14.9% of the variance and included 5 variables (15, 16, 14, 17, 13). The third factor explained 10.88% of the variance and included 4 variables (12, 1, 9, 11). The fourth factor explained 8.31% of the variance and included 2 variables (5, 8). The results of the rotated structure matrix appear on Table 2.

Table 2: Rotated structure matrix of EFA.

Variable/ Sub-category	Factor 1: Task-related activities	Factor 2: Regulation of the process	Factor 3: Regulation of content	Factor 4: Conflict management
7. Agreement/ Consensus	0.83	0.17	-0.07	0.56
4. New Ideas	0.70	0.22	0.32	0.05
3. Transforming	0.61	0.11	0.02	0.22
2. Elaborated Telling	0.59	0.35	0.18	0.37
6. Elaboration/ Expansion	0.53	0.27	0.33	0.10
10. Acknowledgment	0.39	0.21	0.03	0.22
15. Tool-related Talk	0.23	0.80	0.31	0.22
16. Process-related Talk	0.07	0.75	0.22	0.18
14. Monitoring and Planning	0.33	0.65	0.25	0.02
17. Social Talk	0.33	0.51	0.19	0.11
13. Justification/ Clarification	0.18	0.49	0.21	0.27
12. Meta and Prompts	0.19	0.20	0.73	-0.19
1. Telling	0.25	0.23	0.73	-0.08
9. Syntheses/ Summaries	0.01	0.32	0.65	0.13
11. Explanatory Questions	0.10	0.30	0.62	0.22
5. Modification	0.28	0.25	0.14	0.73
8. Disagreement	0.43	0.13	-0.11	0.64

As evident from Tables 1 and 2, the EFA suggested a different factor structure than the one conceptualized in the coding scheme. As a next step, we made an effort to verbally interpret the resulting factors and understand how the variables (sub-categories) may fit together in the collaborative learning process.

Factor 1: The six variables in this factor seem to measure the “*task-related activities*” (i.e., efforts aimed at solving the problem at hand, such as exchange of ideas, agreements, and contributions of supporting information and theoretical perspectives).

Factor 2: Four of the variables in this factor seem to measure the “*regulation of the process*” (i.e., efforts aimed at planning the task); however, the “Justification/Clarification” variable in this factor is not justifiable.

Factor 3: At a first glance, the four variables in this factor do not seem to fit well conceptually. However, assuming the operationalization of variable 1 (telling), it would be reasonable to think that such statements may have triggered questions and prompted further discussion (variable 12 and 13). That is, if one brought into the discussion a piece of information that was not related to the case, s/he was likely to receive a question. In addition, questions and prompts were likely to encourage a synthesis or summary of ideas (variable 9). A closer examination of student discourse provided support for these arguments. As such, the four variables

in Factor 3 can, in fact, make sense conceptually as a measure of “*regulation of content*” (i.e., efforts aimed at understanding all the contributions).

Factor 4: The two variables in this factor seem to measure “*conflict management*” (i.e., presentation of different views and options and modification of ideas).

Table 3: Factor correlation matrix.

	Factor 1: Task-related activities	Factor 2: Regulation of the process	Factor 3: Regulation of content	Factor 4: Conflict management
Factor 1	1.00			
Factor 2	0.28	1.00		
Factor 3	0.17	0.37	1.00	
Factor 4	0.30	0.24	-0.06	1.00

According to the factor correlation matrix presented in Table 3, Factors 2 and 3 were the most highly correlated between each other ($r=0.37$, with a medium effect size), indicating that these factors tend to occur concurrently. Indeed, solving a problem collaboratively seems to involve *regulation of content* (e.g., asking questions or making summaries of ideas) and *planning* (e.g., talk about the process), both occurring concurrently in the collaboration space. Additionally, Factor 1 was correlated with Factor 4 ($r=0.30$) and Factor 2 ($r=0.28$), indicating some sort of similarity among them. This is not surprising assuming all factors measured some aspect of the online collaborative learning process.

Table 4: Cronbach’s coefficient alpha reliabilities.

	# Items	alpha
Factor 1: Task-related activities	6	.76
Factor 2: Regulation of the process	5	.76
Factor 3: Regulation of content	4	.70
Factor 4: Conflict management	2	.62

Following the EFA, for each factor we run Cronbach’s coefficient alpha reliabilities -- a widely used measure of internal consistency. The resulting Cronbach’s alphas for the four factors appear in Table 4. Researchers recommend coefficient alpha levels of at least .70 (see guidelines in Gable & Wolfe, 1993). Thus, alphas for Factors 1-3 were deemed acceptable; alpha for Factor 4 was lower than recommended, but this should be expected considering this factor includes two items only (Gable & Wolfe, 1993).

Discussion

In this study our goal was to foster the replicability and validity of a coding scheme for QCA. We followed a 2-step approach: First, we adapted an existing instrument developed and used in previous research like Rourke and Anderson (2004) and De Wever et al. (2005) recommend. Then, after coding and counting of a large dataset, we employed established methods in quantitative research to examine the psychometric properties of the coding scheme as a measurement instrument.

Unlike we would have expected, the EFA on the coded data suggested a different factor structure than the one conceptualized in the coding scheme. Reliability Analysis showed the internal consistency within the resulting factors was acceptable for the most part. Although we interpreted the resulting factors and understood (at least for the most part) how the variables fitted together, we do not have a good explanation for the inconsistency between the initial structure of the coding scheme and the emerging factors.

We believe this discrepancy is linked to the fact that the theoretical base for the initial development of the coding scheme (Activity Theory, Engeström & Miettinen, 1999) is fundamentally different from the traditional psychology and its psychometric model. In general, CSCL researchers work with epistemological assumptions that are inconsistent with the psychometric model. CSCL studies (and thus the coding schemes they develop for QCA) often emphasize the importance of context in cognition (e.g., Lave and Wenger, 1991) and the socially situated and culturally-mediated nature of CSCL (e.g., Engeström & Miettinen, 1999). Thus, it might be meaningless or even inappropriate to treat a coding scheme as a (quantitative) measurement instrument with psychometric properties such as invariant factor structure, subscale reliability, and instrument validity. On the other hand, however, CSCL studies often report statistical tests on data produced from QCA. In this sense, one would think that validating the coding scheme as a (quantitative) measurement instrument would be meaningful and appropriate before further statistical testing is conducted.

This discussion is by no means complete. Validating coding schemes using well-established quantitative methods, such as EFA and Reliability Analysis, may be a way to achieve rigor in QCA studies and to make coding schemes re-usable and easier to travel across studies. Yet, several questions remain unanswered: Is it appropriate to treat a QCA coding scheme as a (quantitative) measurement instrument to validate it systematically? How the theoretical base for the coding scheme should be considered if a quantitative validation is undertaken? Is it adequate to establish the validity of a coding scheme first theoretically (during its development) and then empirically as Rourke and Anderson (2004) suggest? What are the best procedures to follow in order to foster validity and reliability of coding schemes in QCA?

References

- Chi, M.T.H. (1997). Quantifying qualitative analysis of verbal data: A practical guide, *The Journal of the Learning Sciences*, 6, 271–315.
- Costello, A.B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research and evaluation*, 10 (7), Retrieved November 4, 2010 from <http://pareonline.net/genpare.asp?wh=0&abt=10>
- deWever, B., Schellens T., Valcke, M., & Van Keer H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers and Education*, 46, 6-28.
- Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In H. Spada & P. Reiman (Eds.), *Learning in humans and machines: Towards an interdisciplinary learning science* (pp. 189-211). Oxford: Elsevier.
- Engestrom, Y., & Miettinen, R. (1999). Introduction: Activity theory, a well-kept secret. In Y. Engestrom (Ed.), *Perspectives on Activity Theory* (pp. 1-16). Cambridge: Cambridge University Press.
- Gable, R. K., & Wolfe, M. B. (1993). *Instrument development in the affective domain: Measuring attitudes and values in corporate and school settings*. Boston: Kluwer Academic Publishers.
- Hmelo-Silver, C. E. (2003). Analyzing collaborative knowledge construction: Multiple methods for integrated understanding. *Computers and Education*, 41, 397-420.
- Hmelo-Silver, C. E., & Chernobilsky, E. (2004). Understanding collaborative activity systems: The relation of tools and discourse in mediating learning. In Y. Kafai, W. Sandoval, N. Enyedy, A. Nixon, & F. Herrera (Eds.), *Proceedings of the International Society of the Learning Sciences* (pp. 254-261). Mahwah NJ: Erlbaum.
- Ioannou, A., Bushey, C., & Artino, A. R. (2009, April). *Supporting collaborative learning in online environments: Web 2.0 in an online educational psychology class*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Rourke, L., & Anderson, T. (2004). Validity in quantitative content analysis. *Educational Technology Research and Development*, 52(1), 5-18.
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Acknowledgments

We thank the anonymous reviewers of the first draft of this short paper for their thoughtful comments and suggestions.

Collaboration in Communities of Inquirers: An Example from a Geography Field Trip

Eileen Scanlon, Canan Blake, Alison Twiner, Trevor Collins, Ann Jones, Lucinda Kerawalla, The Open University, Walton Hall, Milton Keynes, UK.

Email: e.scanlon@open.ac.uk, c.tosunoglu@open.ac.uk, a.j.twiner@open.ac.uk, t.d.collins@open.ac.uk, a.c.jones@open.ac.uk, l.j.kerawalla@open.ac.uk

Abstract: Technology supported inquiry learning is a situation rich with possibilities for collaboration and the resultant collaborative learning which may ensue. However the complex settings in which it takes place give researchers a challenge in selecting the appropriate analytic lens. This paper is based on the work of the Personal Inquiry project (PI) which is exploring inquiry learning conducted by students aged 12-15 years across formal and informal settings, and the technology toolkit (nQuire) we have designed to orchestrate the inquiry process. We draw on a case study of geographical inquiry incorporating a field trip and describe the possibilities for collaboration which resulted in this setting. We use a range of data collected before, during and after the field trip to examine the learning behaviours which occurred. We found shifts in behaviour during the field trip, identified different working patterns enabled by the toolkit and identified future areas for research.

Introduction

This paper is based on the work we have conducted as part of the Personal Inquiry: Designing for Evidence-Based Inquiry Learning across Formal and Informal Settings project (the PI project). This project was funded by the Technology Enhanced Learning program (<http://www.pi-project.ac.uk/>). We conducted an investigation into how appropriate support for school students to learn the skills of evidence-based inquiry and investigating could be developed. Our focus in this project is on understanding how learning can be supported across formal and informal settings, and how collaborative learning can be orchestrated in such settings. As is normal in scientific investigations these inquiries are carried out by groups of young people. We are attracted to the description of collaboration offered by Mercer and Littleton (2007, p.25):

‘...participants are engaged in a co-ordinated, continuing attempt to solve a problem or in some other way construct common knowledge... involving a co-ordinated joint commitment to a shared goal, reciprocity, mutuality and the continual (re)negotiation of meaning’

In this paper we will analyse one example of science inquiry conducted in formal education, supported by technology developed in the PI project.

Technology Support for Collaboration

The orchestration of the inquiries involves a range of scientific data gathering equipment such as sensors and cameras managed by a web-based software toolkit (nQuire) that supports students working through the different phases of their scientific inquiries. nQuire provides scripting support for personal inquiry learning (for authoring, orchestration, monitoring, configuring and carrying out inquiries) that encompasses regulatory processes, transformative processes, collaboration and mobility (see Mulholland et al., 2010). It provides teacher support for authoring, orchestrating and monitoring inquiries and student support for carrying out, configuring and reviewing inquiries. nQuire supports opportunities for collaboration by making data available at either individual, group or class levels.

nQuire has been used to define the structure of the inquiry. The Urban Heat Islands phenomena involved data collection by students walking across the centres of two towns. The structure of the inquiry and the experimental design were scripted in participation with the teachers. The prepared structure was then used to guide the students through the data collection and analysis which we are using as the case study of collaboration presented in this paper.

Group Work

We are interested in exploring how technology, and mobile technology in particular, offers the possibility of supporting the transitions made by learners across settings in a range of trials involving young people aged 12-15 years working at school, at home and in settings such as field trips and after school clubs. (See e.g. Scanlon et al., 2009). The group activity we are exploring in this case is the field trip which is important for facilitating learning and conceptual understanding in science education. Jewitt et al. (2001) for instance reinforce the

importance of action in meaning making and we are interested in embodied meaning making in inquiry learning settings.

We are considering the work of two groups of pupils who were collecting data on a field trip. In the first stage students were deciding what to measure and the locations to visit as whole class and as an individual created their own hypothesis for investigation. The pupils were placed into groups to collect their data, in stage 2 and in stage 3 they shared their resultant data with the whole year group, and in turn used other pupils' data in their work, but were required to produce an independent, individual report to submit. (See Figure 1)

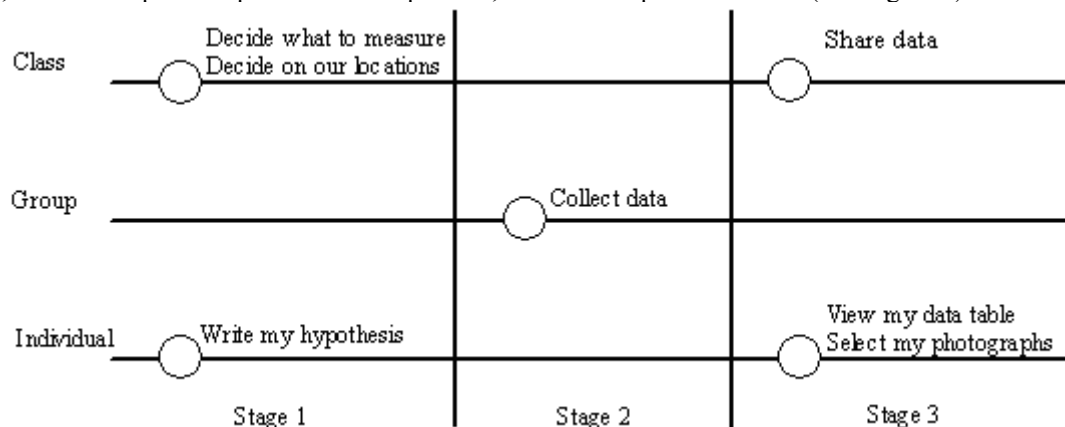


Figure 1. Activities at the Individual, Group and Class Levels within the Urban Heat Islands Inquiry.

The UHI Case Study

This trial was based around students' coursework for a public examination on Urban Heat Islands (UHI). The technical development focussed on supporting the fieldwork aspect of the students' projects. We worked with the whole of year 10 Key Stage 3 classes (aged 14-15 years) that were studying geography at Oakgrove School in Milton Keynes, and their two geography teachers. The 76 pupils were divided into 3 classes. Shared design of the project and the PI toolkit was developed through a series of meetings with the teachers in the term leading up to the students' coursework. Meetings were held with Sciencscope to confirm the best use of sensors and validate the fieldwork methodology. The research was conducted with the approval of the Open University ethics panel, and the school is identified as a research partner.

During the study period, each class attended three geography lessons per week for eight weeks. The sequence of activities is illustrated in Table 1 and includes an introduction to the topic, individual and class working on background and defining hypotheses for the study, fieldwork and presentation of data and analysis.

Table 1: The sequence of UHI inquiry activities over the eight week study.

Week 1	Topic introduction Background research and hypothesis	Week 4	Data collection field trip
Week 2	Methodology specification Student coursework Introduction	Week 5-6	Data presentation
Week 3	Practice data collection	Week 7-8	Data analysis and conclusions

During the fieldtrip, the students used Sciencscope data loggers and sensors to collect wind speed, temperature, infrared irradiance and carbon monoxide data, and took GPS readings of the data collection locations. These were entered into the Personal Inquiry toolkit running on Asus Eee PC netbooks provided to each group of four students, and students were encouraged to add text comments for each location. Cameras were provided to each group to take evidence supporting photographs of locations.

Evaluation

Data from the netbooks was uploaded by the technical research team to a central server that could be accessed by the students from any location (home, school IT suites, etc) through a group login / password. Photographs were saved onto USB drives. An export function in the toolkit allowed students to output data in .xls (Excel) or .kml (Google Earth) formats for representation and visualisation during the write-up period of their project.

We gathered the following data over the study period:

- Audio recordings of meetings with the teachers, and video recordings of a participatory design
- 18 exercise books, coursework journals and coursework

- | | |
|--|--------------------------------|
| workshop | • Teacher resources |
| • Video and audio data (40 hours) from eight weeks of lessons, three lessons a week, for three classes | • 70 post questionnaires |
| Pre and post interviews with teachers and student | • Student webform data |
| post interviews | • Interviews with some parents |

Examples of Group Interactions

In what follows we are looking at whether and to what extent the students engaged in co-operative, collaborative or individual activities and how this changed during the course of the field trip activity. For this we have drawn on Sociocultural Discourse Analysis (SCDA), which adopts a view of language as ‘a social mode of thinking - a tool for teaching-and-learning, constructing knowledge, creating joint understanding and tackling problems collaboratively’ (Mercer, 2004, p. 137). Thus we have largely focused on how talk was used on the field trip. We illustrate below an example of collaboration, which emerged outside of the required data collection activity but still on the field trip, as well as two examples of co-operation. Co-operative group interactions were more common than collaborative exchanges, and manifest in different ways, thus the two examples have been selected to illustrate this. This is supplemented by extracts from the post interviews with the pupils.

In presenting and analysing the examples, we define individual activity as where pupils worked largely on their own in meeting task requirements, such as a pupil taking photographs, or a pupil completing the webform without help from his/her group. Co-operative activity occurred where groups offered their readings to the person inputting information into the netbook, and offered suggestions for the supplementary comments about the surroundings, but did not otherwise engage with or question contributions. Collaboration, as defined above, was less common, characterised by emergent understanding built up through successive exchanges that incorporate and extend previous contributions. The extracts have been chosen to illustrate these forms of talk as they occurred on the field trip. For ease of readability, transcribed extracts have been largely confined to the verbal exchanges, with some information included to indicate a point of reference. The names of pupils involved have been anonymised.

An Example of Collaboration: Discussing Air Temperature

(Elisabeth and Vera having a conversation as they walk along, between data collection stops)

Vera: in hot countries ‘cos they wouldn’t, kind of, do a lot

Elis: Yeah the air temperature would be roughly the same as the irradiance

Vera: It might even be less ‘cos the houses they paint white it reflects it.

Elis: Yeah.

Vera: It would be higher for like irradiance, but it might be a bit lower in terms of the

Elis: But the fluctuations would be lower

Vera: Yeah

Elis: Because of the already existing air temperature.

Within this example we can see how the two girls are building on each other’s responses, but also querying, negotiating and offering countering arguments, in justifying and constructing together a shared and detailed reasoning for their predictions. Thus their joint reasoning emerges out of the collaborative exchange, as their individual experiences and views are juxtaposed through the talk as it unfolds. Such an exchange may not have been anticipated by their teachers, as the girls called upon experiences outside of the school and fieldwork context.

An Example of Co-operation: Helping with Comments Boxes on the Webform

Flora: They’ve all got their engines on

Cath: They’ve all got their engines on which is contributing to the heat

Josh: Yeah, yeah, so like taxis’ engines or whatever
(announcement at station)

Pete: Taxis, sorry what was that?

Cath: Erm, taxis have all got their engines on

Pete (typing): ‘got engines on’. OK cool.

As the day went on, the groups got more used to what they had to do at each collection point, how to use the devices to collect their data, and often what order the person with the laptop wanted the data so that they could enter readings more easily. Their interactions, as in the following example, illustrate how they had established an efficient pattern of working as they co-operated to take and gather their data. This extends to offering suggestions for comments in the free text boxes.

Example of Co-Operation: A Well-oiled Machine for Gathering Readings

Pete: OK. Minimum air temperature.
 (Flora holding up temp sensor, Cath holding wind temp measure)
 Flora: Minimum 7.2, maximum 8.6
 Pete: OK wind speed
 Cath: 0.0 and 1.0.
 Flora: And I've got a picture
 Pete: OK how is the land being used?
 Dan: Like that's gonna work in the corner (wind speed)
 Pete: Shall I put main road
 Cath: Yeah main road
 Josh: Say junction
 Flora: Traffic light
 Cath: Yeah there's traffic lights behind us

Mainly towards the end of the field trip, the groups got tired and were less willing to offer help in writing comments into the webform, thus the work became more individual, and reliant on the person in control of the netbook. The comments groups had to work with when back in the classroom therefore were often dependent on which person was holding the netbook and whether they filled them in.

The group felt using the netbook helped when collecting and inputting the data, and in sharing and using the data back in the classroom. A comment from our group pupil post interviews illustrated this:

Researcher: And how would using that compare to if you were walking around with your books, writing stuff?

P1: It would just be awkward
 P2: awkward
 P1: It was windy...
 P2: the pages might be everywhere
 P1: everywhere.
 P2: And you would just get tired and it would take more time
 P1: Yes, takes ages.
 P2: It would be messy, this one is quite straight, the hand writing you could be really scribbly and you would be like, what's that number?
 P1: Spread it around, but if one person writes it
 Researcher: You could share, that's a good point.
 P2: With that, you can have one copy and share it.'
 Note: individual pupils were not identified in the final interviews.

The webform on the laptop acted as a form of 'guided participation' (Rogoff, 1990), in the field trip as the webform highlighted the type of readings they needed to take and points they should note. There were some suggestions from pupils of how technology could support the data inputting process, particularly with data collection in relation to infrared irradiance, where some pupils commented that they occasionally forgot to add in plus or minus sign for the values.

Groups also showed how they had co-operated on the field trip when talking about the photographs they took to illustrate their data. They commented on the link between what the group entered into the comments boxes on the webform with the pictures taken on the camera, thinking forward to how they would use the textual and image data in writing up their coursework to evidence their findings. A comment from the group pupil post interviews illustrates this:

Researcher: How did you choose which photos to take?
 P1: ... but some of them depended on the comments
 P2: Oh yeah,
 P1: one of them was about traffic lights so we took a picture of the traffic lights.

This identifies that the pupils were utilising the different technologies at their disposal to provide a coherent picture of the data they were collecting – by complementing the text written to describe the area, with data about the temperature, carbon monoxide, infrared irradiance and wind speed readings, with photographic evidence. Thus the pupils potentially had the foresight to consider that when back in their classrooms, they could piece together why certain readings may have been higher or lower at certain points on their trip (e.g. high carbon monoxide readings close to traffic lights where cars would often be at standstill).

Collaboration on the Field Trip

The trajectories of pupils working on this complex inquiry offer a rich source of data through which to consider the collaborative activities undertaken. Our analysis builds on the concept of ‘collaborative emergence’ defined by Sawyer and Berson (2004). They define it as ‘characterised by improvisation, unpredictability, and responses that are contingent on each other’, p390. The authors use this to suggest how group discussions enable a form of understanding created by the group working together, as a sum of all contributions. They suggest the role of external representations in group work, such as maps, photographs, and writing on screen, can ‘enhance the educational benefits of collaborative conversation’ (p390). They define notes pupils make as more than memory dumps – in the group context they can become a source of collective and collaborative discussion, from which to re/create understanding. This was particularly observable in the first example given, where the girls discussed the environmental readings and how they might be influenced by various environmental features. Thus they were going beyond the task requirements (to collect readings at certain points in the cities they were studying), in jointly constructing an understanding of the nature of the factors they were recording, through their emergent discussion that built upon, agreed with or contested each other’s views in improvising and justifying their view in response to their partner.

We are currently analysing episodes from the further seven trials we have conducted on the project (see e.g. Sharples, 2009). So far we have analysed the discourse surrounding collaboration in the urban heat islands field trip and a field trip which took place at a nature reserve on the topic of noise and bird feeding (see Schwegmann et al., 2010).

Conclusions

In the PI project we are interested in exploring how technology and mobile technology in particular, offers the possibility of supporting the transitions made by learners across settings. These settings are an important site for collaborative work and offer the possibility of analysing moves from individual to group working. So far we have identified how our toolkit orchestrated the possibilities for collaborative working and in this paper have given some illustrations, using dialogue during a field trip, of what happens during such an inquiry. We have illustrated how this activity involved co-operative, collaborative and individual activities at different stages and for different reasons. We have presented some evidence that the different working patterns and requirements were recognised. We have not found evidence of ‘ground rules’ established within groups or the classes for how they should interact and work together when collecting data. We now intend to extend this analysis to other examples of orchestrated inquiry learning in our project.

References

- Jewitt, C., Kress, G., Ogborn, J. & Tsatsarelis, C. (2001). Exploring learning through visual, actional and linguistic communication: the multimodal environment of a science classroom. *Educational Review*, 53 (1), 5-18.
- Mercer, N. & Littleton, K. (2007). *Dialogue and the development of children’s thinking: A socio-cultural approach*. London and New York: Routledge.
- nQuire available at <http://www.nQuire.org.uk>
- Mercer, N. (2004). Sociocultural discourse analysis: Analysing classroom talk as a social mode of thinking. *Journal of Applied Linguistics*, 1(2), 137-168.
- Mulholland, P., Collins, T., Gaved, M., Wright, M., Sharples, M., Greenhalgh, C., Kerawalla, K., Scanlon, E. & Littleton, K. (2010). nQuire: A customizable toolkit for inquiry learning across school, field and home locations, Proceedings of MLearn, October 2010, Malta.
- Rogoff, B. (1990). *Apprenticeship in thinking*. New York: Oxford University Press.
- Sawyer, R.K. & Berson, S. (2004). Study group discourse: How external representations affect collaborative conversation. *Linguistics and Education*, 15, 387-412
- Scanlon E., Conole, G., Littleton, K., Kerawalla, L., Gaved, M., Twiner, A., Collins, T. and Mulholland, P. (2009). Personal Inquiry (PI): Innovations in Participatory Design and Models for Inquiry Learning, paper presented at AERA 09, [American Educational Research Association](http://www.aera.net), San Diego, April 13–17, 2.
- Schwegmann, P., Yang, Y., Anastopoulou, S., Ainsworth, S., Paxton, M. & Feisst, M. (2010). Studying collaboration during a field trip inquiry. Paper presented at MLearn, October 2010, Malta.
- Sharples, M. (2009). Methods for Evaluating Mobile Learning. In G.N. Vavoula, N. Pachler, and A. Kukulka-Hulme (eds), *Researching Mobile Learning: Frameworks, Tools and Research Designs*. Oxford: Peter Lang Publishing Group, pp. 17-39.

Acknowledgments

Thanks are due to colleagues in the Personal Inquiry Project, to the teachers and pupils of Oakgrove School, Milton Keynes, and to Sciencscope, our full partners in the study.

Exploring Joint Attention around Shared Referential Anchors during Physical, Virtual and Mixed Reality Laboratory Activities

Garrett W. Smith, Anushree Bopardikar, Sadhana Puntambekar, Department of Educational Psychology, University of Wisconsin-Madison, Madison, WI

Email: gwsmith@wisc.edu, bopardikar@wisc.edu, puntambekar@education.wisc.edu

Abstract: This study explores student collaboration in three types of laboratory environments in middle school inquiry science classrooms: a physical laboratory environment, a virtual laboratory environment, and a mixed reality environment. Based on video of student collaboration across the three types of environments and supplemented with interview data, we analyzed joint attention of students around shared referential anchors across the three environments. Our results indicate that the mixed reality and virtual environments provided several opportunities for joint attention not available in the physical environment, namely opportunities pertaining to the availability and persistence of representations that could act as shared referential anchors. The mixed reality environment also provided advantages over the virtual environment in terms of the visibility of referential anchors to all group members. The implications of these findings and directions for future work are discussed.

Introduction

Within inquiry science classrooms, the two dominant representational forms for student-led inquiry have typically been physical laboratories and computer simulations. Teachers often decide between one or the other representational form based on tradeoffs such as the cost and amount time required for each (Hofstein & Lunetta, 2004). However, research shows that it may be beneficial for students to perform inquiry with both forms, as physical laboratories and computer simulations may have different affordances for learning (Jaakkola & Nurmi, 2008; Smith, Gnesdilow & Puntambekar, 2010).

Since groups of students often use physical laboratories and computer simulations collaboratively, (van Joolingen, de Jong, & Dimitrakopoulou, 2007), it is important to understand the affordances of these representational forms for students' collaboration. Different representations may have different affordances for collaboration (Suthers & Hundhausen, 2003), for example in supporting joint attention. Representations and other material resources may help students sustain joint attention and mutual engagement during collaboration by providing a publicly accessible referential anchor for the co-construction of knowledge (Crook, 1995), and joint attention itself is critical for collaborative learning (Barron, 2000).

There has been growing interest in the use of mixed reality technologies, such as augmented reality and tangible interfaces, for supporting learning and collaboration (e.g., Marshall, 2007; Jermann et al., 2009). In this paper, we describe a mixed reality laboratory environment that combines elements of a physical laboratory and a computer simulation. We then explore student collaboration across the physical, virtual and mixed reality laboratory environments, focusing on students' joint attention around shared referential anchors.

Methods

We performed an exploratory study examining students' face-to-face collaboration around three types of laboratory environments in science classrooms: a physical laboratory environment, a virtual laboratory environment, and a mixed reality physical/virtual environment (see Figure 1). Students in small groups of 3-4 used all three environments to explore physics concepts related to inclined planes. Students engaged with the physical and virtual laboratory environments, within the classroom as part of the CoMPASS simple machines curriculum (Puntambekar, Stylianou & Goldstein, 2007). This curriculum integrates a digital hypertext environment, physical and virtual science experiments, and design challenges within cycles of inquiry. The students engaged with the mixed reality environment after the completion of the curriculum; this was designed to pilot a prototype of the mixed reality environment. For this study, we observed and videotaped one group of four 8th grade students as they engaged with the three environments (see Figure 1). We also interviewed this group as well as five additional groups of 6th grade students (3-4 students per group) about their experiences with all three environments. This study is a step within a larger design-based research program to help students link multiple representations within middle school science inquiry classrooms. For this particular step, we are exploring how blending elements of physical and virtual laboratory environments may support students' learning of science concepts.

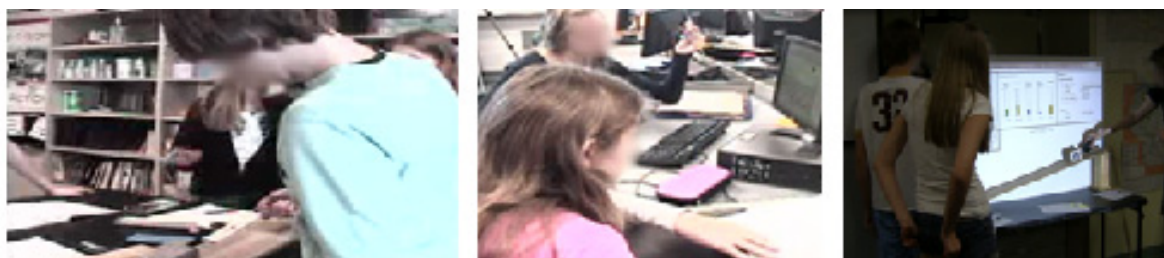


Figure 1. A Student Pulling a Block Up a Ramp in the Physical (Left), Virtual (Center), and Mixed Reality (Right) Environment.

Learning Environments

Across the three environments, students performed an experiment to determine the amount of force and work required to pull an object up different inclined planes. For the physical experiments, students used three different ramps, a support upon which the ramps would rest, a brick to pull up the ramps, and a spring scale to measure the amount of applied force. Students also recorded values of other variables involved in pulling the brick up the ramp.

For the virtual laboratory environment, students used a computer simulation of this inclined plane experiment. Students could change the properties of the inclined planes by inputting numerical values or by controlling sliders. They would then increase the amount of applied force using the slider until there was enough force for the brick to move up the ramp. An animation of the brick moving up the ramp would be displayed, along with numeric values and graphical representations of the amount of force applied and other physics concepts.

The mixed reality environment combined elements of the physical and virtual laboratory environments. Students performed the physical inclined plane experiment while real-time data of the experiment was projected onto the screen. Students also ran the inclined plane simulation in the same space to explore what would happen in situations that would be impractical or impossible to set up with the physical materials (e.g., a frictionless environment). This mixed reality environment utilized an electronic force sensor to measure the force applied in moving the brick up the inclined plane, a webcam and fiducial markers to detect the position and orientation of the brick, and an infrared pen and two Nintendo Wii remotes to allow students to use the screen as an interactive whiteboard (Lee, 2008). For all three environments, students recorded their results in a table provided in a workbook.

Data Sources and Analysis

We videotaped one group of four 8th grade students as they completed the physical and virtual inclined plane experiments in the classroom setting and engaged with the mixed reality environment in a laboratory setting. The videos consisted of 16 minutes for the physical environment, 14 minutes for the virtual environment, and 13 minutes for the mixed reality environment, for a total of 43 minutes of video. For the physical and mixed reality environments, the four students worked as a whole group; for the virtual environment, students worked in pairs with each pair at a separate computer. We also conducted open-ended interviews with six groups of 3 to 4 students (including the videotaped group) after they used the mixed reality inclined plane environment, to ask students about their preferences for using these environments.

We analyzed video data through a combination of an inductive and deductive approach (Patton, 1990). The overall focus on shared referential anchors during collaboration was derived from previous literature, and the specific subcategories of the use of referential anchors were developed inductively from both the student interviews and video data. For the video data, we first coded instances of joint attention around shared referential anchors. We defined an instance of joint attention around a shared referential anchor as one or more members of the group talking about a material resource or representation in the environment (e.g. spring scale, notebook or digital representation) with at least one other member viewing the same reference. We further divided the overall instances of talk around shared referential anchors into several subcategories. The first subcategory was whether each instance of talk constituted only the reporting of data to other group members or whether the talk consisted of more extended conversations about these shared referential anchors. The second subcategory was the specific representations that served as referential anchors. These could include measurement equipment in the physical laboratory environment (e.g. spring scale or meter stick), inscriptions within the student notebooks, or digital representations (e.g. graphs, vectors or numerical values) in the virtual or mixed reality environments. Additionally, a second part of this subcategory was which specific science concepts were represented by the referential anchors. The third subcategory was the timing of these instances: either during a trial in the experiment (i.e., during the process of pulling the brick up the ramp) or after a trial. The final subcategory was the number of students in the group viewed the representation at the time that the talk

occurred. To establish inter-rater reliability, the first two authors independently coded the entire corpus of video data. Inter-rater agreement was 88% for coding total instances of talk around shared referential anchors and 91% for coding the subcategories. All discrepancies in coding were resolved through discussion. We then used the interview data to shed light on our understanding of the video data.

Results

In this section, we first describe differences in instances of joint attention around shared referential anchors across the three environments, and then analyze the subcategories of these instances: the extent of the conversation around the referential anchors, the specific referential anchors utilized, the timing of the instances of joint attention, and the visibility of the referential anchors to all group members. For each of these subcategories, we analyze whether there may be potential advantages of one learning environment over the others in supporting joint attention through the availability of shared referential anchors.

Our analysis showed that there were differences in the total number of instances of joint attention around a referential anchor (see Table 1). While students used referential anchors 10 times each in the virtual environment and mixed reality environments, they only did so 6 times in the physical environment. Furthermore, there were differences in the levels of talk around the shared referential anchors. In the physical environment, 5 out of 6 instances of joint attention involved only reporting data (either from the spring scale or from their notebook) to other group members, whereas one instance involved extended discussion beyond reporting of data. For the virtual environment, 8 of 10 instances of joint attention involved only reporting data, whereas 2 instances moved beyond reporting data to more extended discussions around the data. For the mixed reality environment, 6 out of 10 instances involved only reporting data, while 4 instances of joint attention around shared referential anchors included extended talk beyond reporting of data. Below we describe potential advantages of the mixed reality and/or virtual environments (based on subcategories pertaining to group discourse around shared referential anchors as well as interview data) that may shed light on these differences in group discourse.

Table 1: Instances of group discussion around a shared referential anchor by laboratory environment.

Laboratory Environment	Total Instances of Joint Attention around Referential Anchor	Reporting Only or Extended Conversation	Concepts Represented (Representation Types)	When Instances Occurred	Group Members Viewing Referential Anchor
Physical	6	5 reporting, 1 extended	5 applied force (spring scale) 1 other concept (notebook)	5 during trial, 1 between trials	2-3
Virtual	10	8 reporting, 2 extended	4 applied force (numeric, vector) 5 other concepts (numeric)	1 during trial, 8 between trials	2
Mixed Reality	10	6 reporting, 4 extended	1 applied force (numeric) 9 other concepts (numeric, graph)	4 during trial, 5 between trials, 1 both	3-4

One potential advantage of both the mixed reality and virtual environments over the physical environment was the availability of additional representations that could serve as referential anchors. The virtual and mixed reality environments offered both representations of variables (e.g. work and potential energy) and types of representations (e.g., graphs, numerical values) that were not immediately present in the physical environment. In the virtual and mixed reality environments, students used numeric as well as other representations for joint attention, while in the physical environment, students used the spring scale as a referential anchor on 5 of 6 occasions, and used one student's notebook on one other occasion. In the mixed reality and virtual environments, students also attended to representations of variables (e.g., potential energy, efficiency) that were not immediately available in the physical environment (see Table 1).

A related potential advantage of the mixed reality and virtual environments over the physical environment was the persistence of these representations after each experimental trial was complete (see Figure 2). With physical experiments, students individually wrote down values of applied force from the spring scale, and then could potentially use this inscription in their individual data tables to reason about the data across trials. In contrast, all of the representations provided in the mixed reality and virtual environments during an experimental trial would persist after the trial was complete, providing students with a persistent referential

anchor to publicly make meaning of the data. In the example on the right side of figure 2, one student is pointing toward a graphical representation of work and stating to her group members, “I think work output never changes, because the last time it was [the same].” While in the physical experiment there was only one instance of joint attention around shared referential anchors after a trial (via a student notebook), 8 of the instances in the virtual environment and 5 of the instances in the mixed reality environment occurred between trials (see Table 1).



Figure 2. Students Recording Data after Running a Trial in the Physical (Left) and Mixed Reality (Right) Environments.

One potential advantage of the mixed reality environment over the other two environments was the visibility of the representations to all group members (see Figure 2). By projecting the data onto a larger space, the mixed reality environment allowed the representations to be visible to all students. During the interviews, one group reported difficulty in viewing the spring scale (in the physical experiment?): “I like [the mixed reality environment] cause you don’t have to [try to see the]spring scale.” The video analysis showed that, in the physical environment, only 2 or 3 students could view the value of the spring scale each time the brick was being pulled up the ramp. In contrast, in the mixed reality environment, all students in the group could view the representations presented. Since the videotaped group worked in dyads during the virtual experiment, all group members could see the virtual experiment on one of the two computers, though this restricted instances of joint attention to two of the four group members. In most of our classroom implementations, however, students use laptops in groups of 3 or 4 due to the number of computers available. Of the groups that had performed the virtual experiments in groups of 3 or 4, several students mentioned that they were better able to see everything in the mixed reality environment than in the virtual environment: “It’s a big screen so everybody can see it;” “I like doing it up here cause you can see it better.”

Discussion

Our findings indicate that the mixed reality and virtual environments may offer more opportunities for joint attention among group members than the physical laboratory environment, and that the mixed reality environment may offer more opportunities for extended discussion around a shared referential anchor than either the physical or virtual environments. As with the virtual laboratory environment, the mixed reality environment provides a referential anchor for the applied force that is more visible to all group members than the spring scale in the physical environment. Both the mixed reality and virtual laboratory environments also provide additional types of representations (i.e. numeric, graphical) as well as representations of additional variables (e.g. work, energy) that can serve as referential anchors and that are not available in the physical environment. These representations persist after a trial is completed, which may allow students to use these representations as referential anchors and to co-construct their understanding of the variables even after the trial is complete. Furthermore, the mixed reality environment improves on the virtual environment in that the representations are on a larger screen and are thus more easily visible for all group members and potentially more likely to serve as referential anchors for all members of the group. The availability of these referential anchors in the mixed reality environment may promote mutual engagement and joint attention (Crook, 1995), which are important for students’ collaboration (Barron, 2000). In this study, the greater number of instances of joint attention in the virtual and mixed reality environments may potentially be attributed to the availability of additional representations as well as their persistence after the completion of experimental trials. The greater frequency of extended discourse surrounding the referential anchors in the mixed reality environment may be attributed to the visibility of the representations to all group members; having only a few members able to view referential anchors within the physical and virtual environments may have led to the greater proportion of only reporting data within these environments.

There are additional opportunities for collaboration that could be incorporated into the mixed reality environment. According to Crook (1995), when designing environments for joint activity, we should allow students to perform publicly visible, concrete manipulations with the referential anchors. With this in mind, the mixed reality environment could be designed to further support manipulations of the available representations.

In digitizing the data from students' physical experiments, the mixed reality environments could provide even more flexible and persistent representations, for example allowing students to view and manipulate graphs and tables of their data across many trials. Having these representations available through the system could provide additional referential anchors that could be more easily shared across group members than their current hand-written data tables in their workbooks. Such publicly available representations that persist across time may allow students to utilize their prior activity as a learning resource (Suthers, 2006).

Overall, this study shows that a mixed reality laboratory environment may provide opportunities for collaboration through the availability of shared referential anchors that go beyond what is available in traditional physical and virtual experiments. It also describes several dimensions of the availability of referential anchors (including their persistence and visibility to all group members) that may be important to consider when designing such environments for collaborative learning. Though in this paper we described opportunities for collaboration across three different learning environments, we did not assess students' understanding as it relates to these opportunities. Additionally, with a small sample and without counterbalancing the sequence in which the three environments were presented, it is unclear whether our results are due largely to the learning environments or to the sequence of these environments. In future work, in classrooms with a larger sample, we will investigate how the opportunities for joint attention identified here contribute to students' learning.

References

- Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *Journal of the Learning Sciences*, 9(4), 403-436.
- Crook, C. (1995). On resourcing a concern for collaboration within peer interactions. *Cognition and Instruction*, 13(4), 541-547.
- Hofstein, A., & Lunetta, V. (2004). The laboratory in science education: Foundations for the twenty first century. *Science Education*, 88(1), 28-54.
- Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning*, 24(4), 271-283.
- Jermann, P., Zufferey, G., Schneider, B., Lucci, A., Lépine, S., & Dillenbourg, P. (2009). Physical space and division of labor around a tabletop tangible simulation. In *Proceedings of the 8th International Conference on Computer Supported Collaborative Learning (CSCL 2009)*, Rhodes, Greece, June 8-13, 2009.
- Lee, J. (2008). Hacking the Nintendo wii remote. *Pervasive Computing, IEEE*, 7(3), 39-45.
- Marshall, P. (2007). Do tangible interfaces enhance learning? *Tangible and embedded interaction: Proceedings of the 1st international conference on tangible and embedded interaction*, February 15-17, 2007.
- Patton, M. (1990). *Qualitative evaluation and research methods*. Thousand Oaks, CA: Sage Publications, Inc.
- Puntambekar, S., Stylianou, A., & Goldstein, J. (2007). Comparing classroom enactments of an inquiry curriculum: Lessons learned from two teachers. *The Journal of the Learning Sciences*, 16(1), 81-130.
- Smith, G.W. & Puntambekar, S. (2010). Examining the combination of physical and virtual experiments in an inquiry science classroom. *9th International Conference on Computer Based Learning in Science*, Warsaw, Poland.
- Suthers, D. (2006). Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning*, 1(3), 315-337.
- Suthers, D., & Hundhausen, C. (2003). An experimental study of the effects of representational guidance on collaborative learning processes. *Journal of the Learning Sciences*, 12(2), 183-218.
- Van Joolingen, W., De Jong, T., & Dimitrakopoulou, A. (2007). Issues in computer supported inquiry learning in science. *Journal of Computer Assisted Learning*, 23(2), 111-119.

Acknowledgements

CoPASS research is supported by the National Science Foundation: IERI #0437660 & Institute of Educational Sciences: CASL #R305A08050

E-Tutorial Support for Collaborative Online Learning: Differences between Experienced and Non-experienced E-tutors

Birgitta Kopp, Ludwig-Maximilians-Universität, Munich, Leopoldstr. 13, D-80802 Munich, Germany,
birgitta.kopp@psy.lmu.de

Maria Cristina Matteucci, Alma Mater Studiorum Bologna, Via Filippo Re, 6, I-48018 Cesena, Italy,
mariacristina.matteucci@unibo.it

Carlo Tomasetto, Alma Mater Studiorum Bologna, Via Filippo Re, 6, I-48018 Cesena, Italy,
carlo.tomasetto@unibo.it

Heinz Mandl, Ludwig-Maximilians-Universität, Munich, Leopoldstr. 13, D-80802 Munich, Germany,
heinz.mandl@psy.lmu.de

Abstract: This study investigated differences between experienced and non-experienced European e-tutors in their support of online collaboration. We developed a questionnaire e-tutors had to fill in to evaluate specific collaborative activities and to answer yes/no-questions regarding their intervention to support these collaborative activities. 78 e-learning experiences from 17 different European countries were included. Cluster analysis was conducted to cluster e-tutors into sub-groups that have similar response patterns. Results indicated two clusters, namely cluster 1 with experienced e-tutors and cluster 2 with less experienced e-tutors. E-tutors of cluster 1 evaluated collaborative activities more important than e-tutors of cluster 2 and they reported to intervene more often to foster such activities. These findings show the importance of expertise in e-tutoring: E-tutors with experience consider more deeply the importance of specific cognitive activities for effective online collaboration, they are more familiar in detecting dysfunctional social phenomena and in adequately intervening to avoid such phenomena.

Theoretical Background

Virtual collaborative learning is being used increasingly in different learning contexts. This is due to the fact that collaborative learning has several benefits, e.g. supporting knowledge application (De Corte, 2003). But collaborative learning is not successful when used in isolation (Salomon & Globerson, 1989). There are many pitfalls in collaborative learning such as social loafing (Latané, Williams & Harkins, 1979), free riding (Kerr & Bruun, 1983) or the lack of clear responsibilities in collaborative task solving. Therefore, support is necessary.

Support for virtual collaboration and collaborative learning is often realized by the e-tutor. E-tutors are defined according to their main function, which is to supervise learners. According to this perspective, e-tutoring comprises all the activities of a teacher that support a learner in constructively and actively handling the learning environment (Kopp, Germ, & Mandl, 2010).

Main collaborative activities in virtual learning environments which should be supported by e-tutors are especially content-specific cognitive, social activities (Kopp, & Mandl, 2011), and meta-cognitive activities. *Cognitive activities* include knowledge exchange (dissemination of shared and unshared knowledge between group members), online discussion (deeply discussion different points of view), argumentation (justifying different points of view), collaborative problem solving, and considering different perspectives. Regarding *social activities*, the focus is on the motivation of the group members (Elliot & McGregor, 2001), interpersonal interaction (Nemeth, 1986), social influence processes (e.g., ignoring minorities, imposing conformity upon group members), and information processing (e.g., superficial discussion, addressing the e-tutors rather than group members). *Meta-cognitive activities* are essential for self-guided collaborative learning. In this context, planning/organizing, monitoring and regulating collaborative learning are main strategies. While the planning and organizing of collaborative activities takes often place before collaborative learning and includes the choice of specific strategies, monitoring and regulating collaborative activities are essential during the collaboration process. With help of an actual-theoretical-comparison, the learning success is evaluated (Schreblowski, & Hasselhorn, 2006). Based on the results of this evaluation process, regulation takes place when it is necessary.

Even though specific cognitive, social, and meta-cognitive activities are essential for effective learning, the question is how e-tutors support such collaborative activities in practice. On a theoretical basis, there are especially two possibilities of supporting online collaboration: providing specific structures in the virtual learning environment like scripts or directly intervening during the collaborative learning process (Kopp, & Mandl, 2011). In e-tutoring, direct intervention using feedback is of main importance. Providing feedback which “is conceptualized as information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one’s performance or understanding” (Hattie, & Timperley, p. 81), is very helpful to prevent the student’s sense of being totally alone and unguided (Schweizer, Paechter, & Weidenmann, 2001)

and to specifically react on problems of the learners. The objective of giving feedback is to reduce the discrepancies between the student's current understanding and a desired goal.

E-tutors themselves who are main agents responsible for the delivery of the courses and the support of the learners, must be equipped with an appropriate set of skills in addition to subject matter expertise (McPherson, & Nunes, 2004). As e-tutoring differs in number of ways since e.g. it places greater emphasis on written skills, produces a more formal tone, promotes multiple conversations, or requires teachers to assess the worth of online contributions (McPherson, & Nunes, 2004), it seems necessary that e-tutors are experienced in fostering online learning. Research on the experience of e-tutors show that more experienced e-tutors post more contributions in their courses (Goold, Coldwell, & Craig, 2010), give more direct instructions and feedback, and deal more often with pedagogical knowledge than novice tutors (Maor, 2008). But there is no literature on the way how experienced e-tutors differ from non-experienced e-tutors in their practical support behavior when fostering online collaboration. Therefore, in this study we had a closer look at differences regarding e-tutorial support and particularly at the role of e-tutors' experience.

Research Question: Do Experienced and Non-experienced e-tutors Differ in Supporting Online Collaboration?

As experienced e-tutors already know how collaboration in virtual learning environments functions, the assumption is that experienced e-tutors differ in their support from non-experienced e-tutors in that way that experienced e-tutors support collaborative online learning to a greater extent than non-experienced e-tutors.

Method

Sample

The sample comprised a total of 78 online courses from 17 different European countries described by e-tutors. 74.4% were experiences within higher education/university courses, 19.2% were lifelong learning experiences. Inclusion criteria were as follow: (a) the respondent is a teacher, an instructor, or a tutor of an e-learning course (or, otherwise, he/she knows the experience sufficiently to give details about it); (b) the course is ongoing or it has been delivered in recent past; (c) the course is/has been delivered in blended or full-distance modality; (d) the course include online social interaction activities/collaborative learning activities (such as cooperation, etc.).

Procedure of the Study

A research team including researchers from five European countries (Italy, Germany, Finland, Switzerland, and France) contacted colleagues who were involved in e-learning experiences and invited them to complete a questionnaire on their e-learning experiences. In July 2007, all e-tutors received access to an online questionnaire in their language and were asked to answer this questionnaire for every e-learning experience they offered.

Instrument

An online questionnaire was created in order to get further insights into the way, e-tutors support online collaboration. In the questionnaire, collaborative activities were asked for, especially content-specific cognitive aspects, social aspects, and meta-cognitive aspects of collaboration as well as giving feedback. Regarding the *content-specific cognitive* aspects of collaboration, the questionnaire included five main activities: knowledge exchange, online discussion, argumentation, collaborative problem solving, and considering different perspectives. Each e-tutor was firstly asked on a six-point Likert scale (from 1, *not important*, to 6, *very important*) how important he or she evaluates these dimensions for collaborative online learning. In the second step, e-tutors were asked whether they intervened to foster the specific collaborative activity. In a third step, they were asked if yes, how they intervened and if no, why they did not intervene in an open format.

The questionnaire also asked e-tutors to evaluate *social activities*, namely motivation of the group members, interpersonal interaction, social influence processes and information processing. Regarding motivational aspects, two dimensions were investigated, namely different group goals (2 items) and dysfunctional competition. Interpersonal interaction included phenomena such as dysfunctional interpersonal conflicts, balanced participation, and diffusion/lack of responsibility. Social influencing factors were ignoring minorities and putting pressure on group members. Information processing included the sub-dimensions superficial discussion to avoid conflicts and addressing the e-tutor rather than group members (2 items). In the questionnaire, e-tutors were first asked whether they intervened to avoid such a dysfunctional phenomenon. If they answered yes, they were asked how they intervened, and if no, they were asked why they did not intervene.

Meta-cognitive activities included the planning and organization of group work. In this context, e-tutors were firstly asked how important they rate these activities for collaboration and secondly, whether they intervened to support these activities or not. If they answered yes, they were asked how they intervened, and if no, they were asked why they did not intervene.

Feedback was distinguished in feedback on the task and on the process level. *Feedback on the task level* included the final product of the collaborative work, while *feedback on the process* included two questions on content-related feedback and on feedback on group activities. Again e-tutors were asked how they evaluate the respective feedback and whether they gave such kind of feedback in their respective e-learning course. Furthermore, regarding the final product, e-tutors were asked how they evaluated the final product, using seven criteria, namely knowledge gain, knowledge application, understanding of the content, creativity, ability to collaborate, mastery/skillfulness, and effort, and which procedure they used for evaluation, namely tests, essays, collection of documents, quality of online participation, and observation of collaboration.

Data Analyses

We used the TwoStep cluster methodology to explore the data. The algorithm selected the optimal number of clusters based on either the Schwarz Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC). We used separate t-tests and chi-square tests on variable(s) not used to form the clusters to test the validity of the cluster solution. We compared the clusters based on their response type across the various categories of support activities in terms of past experience of e-tutors, feedback practices and intervention rate.

Results

The cluster analysis identified two clusters whose stability was ascertained until 75 % of the sample size. Cluster 1 ($n=51$; 65.4%) comprised e-tutors who evaluated cognitive activities more important than e-tutors included in cluster 2 ($n=24$; 30.8%) (see table 1). Furthermore, e-tutors of cluster 1 reported to intervene more often to foster cognitive activities in online collaboration than e-tutors of cluster 2 (see table 2). Regarding social activities, e-tutors of cluster 1 reported to intervene more often than e-tutors of cluster 2 (see table 3). Furthermore, regarding meta-cognitive activities, e-tutors included in cluster 1 affirmed to promote more often long-term planning than e-tutors included in cluster 2 (see table 4).

Table 1: Results of e-tutor's evaluation of cognitive activities.

Clustering Items	Cluster 1 (n=51)			Cluster 2 (n=24)		
	<i>M</i>	<i>SD</i>	<i>z</i>	<i>M</i>	<i>SD</i>	<i>z</i>
How important was it for you...						
... to have participants exchange their knowledge?	5.41	(.90)	.14	4.83	(1.76)	-.29
... to have participants involved in content-related online discussion?*	5.47	(.09)	.20	4.58	(1.95)	-.44
... to have participants involved in argumentation?*	5.33	(1.07)	.26	4.08	(2.00)	-.54
... to have participants work together online on problems and cases?	4.90	(1.58)	.10	4.13	(2.27)	-.31
... to have participants integrate their different perspectives?	5.25	(1.00)	.13	4.63	(2.28)	-.27

* $t(73) = 2.70, p = .009$; ** $t(73) = 3.53, p = .001$

Table 2: Results of e-tutor's evaluation of intervention rate for cognitive activities.

Clustering Items	Cluster 1 (n=51)		Cluster 2 (n=24)	
	<i>yes</i>	<i>no</i>	<i>yes</i>	<i>no</i>
Did you intervene to promote...				
... the exchange of knowledge/information?	46	5	10	14
... content-related online discussion?*	48	3	14	10
... argumentation?*	46	5	13	11
... collaboration in problem solving?*	48	3	14	10
... the integration of different perspectives?*	40	11	8	16

* $p < .05$ according to Chi-Square Test

Table 3: Results of e-tutor's evaluation of intervention rate for social activities.

Clustering Items	Cluster 1 (n=51)		Cluster 2 (n=24)	
	<i>yes</i>	<i>no</i>	<i>yes</i>	<i>no</i>
Did you intervene to avoid such a phenomenon				
... individual goals (different group goals I)*	21	30	1	23
... outcome than process (different group goals II)*	23	28	0	24
... dysfunctional competition*	16	35	2	22
... dysfunctional conflicts	21	30	5	19

... balanced participation*	30	21	7	17
... lack of responsibility*	27	24	2	21
... ignoring minorities	20	31	6	18
... putting pressure on group members*	21	30	1	23
... superficial discussion (in order to preserve positive relationships)*	24	27	5	19
... content-related questions to get a response (addressing to the e-tutor I)*	35	16	3	21
... turning to e-tutor (addressing to the e-tutor II)*	38	13	4	20

* $p < .05$ according to Chi-Square Test

Table 4: Results of e-tutor's evaluation of intervention rate for meta-cognitive activities.

Clustering Items	Cluster 1 (n=51)		Cluster 2 (n=24)	
	<i>yes</i>	<i>no</i>	<i>yes</i>	<i>no</i>
Did you intervene to promote long-term planning?*	35	16	3	21
Did you intervene to support participants in the organization of group work?	34	17	11	13

* $p < .05$ according to Chi-Square Test

Validity of the two cluster solutions was evaluated by testing group differences on variables that were theoretically or empirically related to each cluster. We used as cluster validation items concerning the past experience of e-tutors in designing and realizing online courses. We expected e-tutors with experience to be over-represented in cluster 1, which was confirmed by a chi-square analysis. The great majority of e-tutors with past experience in designing and realizing e-learning courses belonged to cluster 1, ($\chi^2(1, n = 75) = 11.75, p < 0.01$).

Furthermore, we examined the e-tutor's feedback looking at the feedback rate (see table 5) and at the final product used to evaluate the collaborative work of the participants and at the procedure used for evaluation using t-test analyses. E-tutors classified in cluster 1 significantly affirmed to use more feedback on the process and on the task solution than e-tutors without experience.

Table 5: Results of e-tutor's evaluation of intervention rate for feedback activities.

Clustering Items	Cluster 1 (n=51)		Cluster 2 (n=24)	
	<i>yes</i>	<i>no</i>	<i>yes</i>	<i>no</i>
Did you evaluate or rate the on-going activities of the collaborative work?*	35	16	2	22
Did you give feedback related to group activities?*	40	11	8	16
Did you evaluate or rate the final product of the collaborative work?*	42	9	13	11
Did you give content-related feedback to your participants?*	48	3	19	5

* $p < .05$ according to Chi-Square Test

Regarding the criteria and procedure of giving feedback, there were significant differences between six out of twelve dependent variables (as for criteria "understanding of the content", $t(53)=2.67, p=.01$.; "creativity", $t(53)=2.38, p=.02$.; "mastery/skilfulness", $t(53)=2.23, p=.03$.; and "effort", $t(53)=2.23, p=.002$.; as for procedures: "quality of online participation", $t(53)=2.11, p=.04$.; and "observation of collaboration", $t(53)=3.09, p=.003$.). As expected, e-tutors of Cluster 1 agreed significantly more often than e-tutors of Cluster 2 to the respective evaluation criteria for the final product of collaborative learning.

Discussion

On the basis of a cluster analysis, it was possible to build two clusters with experienced and less experienced e-tutors. These two groups differ in various dimensions, when they were asked with a questionnaire concerning their daily practice. Experienced e-tutors evaluate specific collaborative activities and feedback in online learning as more important than non-experienced e-tutors, they reported to intervene more often to promote specific activities respectively to avoid dysfunctional phenomena and they affirmed to give more feedback on the collaborative process and on the task solutions. According to these data analyses, it seems that experienced e-tutors are more sensitized to the problems and pitfalls of virtual collaboration than e-tutors without experience, e.g. in detecting dysfunctional social phenomena.

Overall, e-tutors with experience seem to have more knowledge about collaboration processes, problems and pitfalls. Therefore, e-tutors evaluate the importance of specific collaboration activities higher and intervene more frequently in order to foster desired activities and outcomes and in order to avoid unwanted difficulties. To guarantee adequate support and supervision in online collaboration it seems to be necessary that all e-tutors are trained regarding their specific competencies, skills and roles as e-tutor. What we do not know according to our study is, whether experienced e-tutors just intuitively support online collaboration in their daily practice or whether they have the theoretical and empirical knowledge as basis on which they act in a reflected and profound way.

Importance of the Study

This study shows that experience in supporting e-learning groups is an essential precondition for evaluating relevant collaborative activities higher and in adequately intervening for fostering the interaction between group members. Furthermore, feedback as a key antecedent for learners to effectively deal with difficult problems in online collaboration is also more frequently used by experienced e-tutors in their daily practice. Even though, the analyses are based on subjective evaluation data of the e-tutors and on reported self-descriptions of past experiences on e-tutoring, this study gives a first indication that experience has an impact on the way to support online collaboration. To gain such experience, trainings of e-tutors seem to be essential – in adequately evaluating specific collaborative activities as well as in detecting dysfunctional group phenomena which may otherwise inhibit effective group work.

References

- De Corte, E. (2003). Designing learning environments. In L. Verschaffel, N. Entwistle, & J. J. G. v. Merriënboer (Eds.), *Powerful learning environments: Unravelling basic components and dimensions* (pp. 21-33). Amsterdam, The Netherlands: Pergamon.
- Elliot, A. J., & McGregor, H. (2001). A 2x2 achievement goal framework. *Journal of Personality and Social Psychology*, 80 (3), 501-519.
- Goold, A., Coldwell, J., & Craig, A. (2010). An examination of the role of the e-tutor. *Australasian Journal of Educational Technology*, 26(5), 704-716.
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112.
- Kerr, N.L., & Bruun, S. (1983). The dispensability of member effort and group motivation losses: Free rider effects. *Personality and Social Psychology Bulletin*, 44 (1), 78-94.
- Kopp, B., & Mandl, H. (2011). Supporting virtual collaborative learning using collaboration scripts and content schemes. In F. Pozzi, & D. Persico (Eds.), *Techniques for Fostering Collaboration in Online Learning Communities: Theoretical and Practical Perspectives* (pp. 15-32). Hershey (NY): IGI Global.
- Kopp, B., Germ, M., & Mandl, H. (2010). Supporting virtual learning through e-tutoring. In B. Ertl (Ed.), *E-Collaborative Knowledge Construction: Learning from Computer-Supported and Virtual Environments* (pp. 213-230). IGI Global: Hershey (NY).
- Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, 37 (6), 822-832.
- Maor, D. (2008). Changing relationship: Who is the learner and who is the teacher in the online educational landscape? *Australasian Journal of Educational Technology*, 24(5), 627-638. <http://www.ascilite.org.au/ajet/ajet24/maor.html>.
- McPherson, M., & Nunes, M.B. (2004). *The Role of Tutors as an Integral Part of Online Learning Support*. [Available under: http://eprints.whiterose.ac.uk/999/1/Maggie_MsP.html]
- Nemeth, C. J. (1986). Differential contributions of majority and minority influence. *Psychological Review*, 93(11), 23-32.
- Salomon, G., & Globerson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research*, 13(1), 89-99.
- Schreblowski, Stephanie u. Hasselhorn, Marcus (2006). Selbstkontrollstrategien: Planen, Überwachen, Bewerten. In Heinz Mandl u. Helmut Felix Friedrich (Hrsg.), *Handbuch Lernstrategien* (S. 151-161). Göttingen: Hogrefe.
- Schweizer, K., Pächter, M., & Weidenmann, B. (2001). A field study on distance education and communication: Experiences of a virtual tutor. *Journal of Computer Mediated Communication*, 6(2).
- Tenenbaum, G. & Goldring, E. (1989). A meta-analysis of the effect of enhanced instructions: Cues, participation, reinforcement and feedback and correctives on motor skill learning. *Journal of Research and Development in Education*, 22, 53-64.

Acknowledgments

This project ("Social networks and knowledge construction promotion in e-learning contexts", <http://minerva.ing2.unibo.it>) has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein. Authors acknowledge project partners and the EACEA.

The Impact of Interaction Analysis Graphs on Groups during Online Collaboration through Blogs According to the “Learning by Design” Scenario

Georgios Fessakis, Angelique Dimitracopoulou, Aggelos Palaiodimos, Learning Technology & Educational Engineering Laboratory, University of the Aegean, Demokratias 1, 85100 Rhodes, Greece,
Email: gfesakis@rhodes.aegean.gr; adimitr@aegean.gr; psemms07036@rhodes.aegean.gr

Abstract: This paper presents empirical research results about the impact of Interaction Analysis (IA) graphs to groups of students collaborating through online blogging according to a “learning by design” scenario. The IA graphs used are of two categories, the first category summarizes quantitatively the activity of the users for each blog permitting the comparison of students’ activity level in a group while the second category permits the comparison among different groups. The statistical analysis of the students’ interactions shows significant impact of the graphs presence to the number of posts and comments produced by the groups. Furthermore the graphs of the first category (intra-group IA) have stronger consequences than the graphs of the second (intergroup IA). The results support the general claim that interaction analysis is an important component for self regulation in computer supported collaborative learning environments.

Introduction

Increasing interest has recently marked for the utilization of social software (Allen, 2004) by the educational community. This happens not only due to the currently increased availability of social applications of the internet (e.g. web 2.0 services) but also because they are consistent to modern learning theories. Indeed, educational use of social software is obviously consistent to sociocultural theory (Vygotsky, 1986) and to the social constructivism (Kim 2001). These theories advocate the importance of learners’ interaction during active participation to learning activities which provide for design and construction of meaningful artefacts. Blogs (Blog, 2010) constitute special instance of social software that is a network application supporting groups of actors in communication and interaction. In a general overview of educational uses of blogs Downes (2004) notices that students participating in blogging have opportunities to a) reflect on their texts; b) engage in writing for significant time intervals; and c) trigger long dialogue with their readers leading to new writing cycles.

Several case studies provide evidence about feasibility and benefits of using blogs in learning environments. For example Makri and Kynigos (2007) describe a case study is concerning the integration of group blogging in a postgraduate course in Mathematics Education. From the preliminary research data analysis, the researchers underline the possibility of the development of a long-lasting “warm”-informal dialogue and non-monologue narration emerging collaboratively. In Chen et al. (2005) the researchers integrated blogging with the learning portfolio approach showing the importance of the adoption of a well-defined pedagogical approach for the successful integration of blogs or any other content management model (e.g. wikis). The study of the impact of the kind of work or the genre of learning activity (e.g. project, problem solving, brainstorming etc) to the educational blogging appears as interesting research direction. Fessakis et al. (2008) studied the combination of blogs to learning by design pedagogical approach and claim that teachers can utilize blogs in order to increase the communication and interaction in general among the students as well as their participation and engagement level. In this paper an extension of this work is presented concerning the quantitative interaction analysis of groups collaborating for learning by design activities through blogging.

Computer based Interaction Analysis (IA) is an emerging field (Dimitracopoulou, 2008) aiming at supporting directly or indirectly the participants in technology mediated activities. There are two main complementary directions of IA according to the end user of the information produced. In the first direction the IA informs the adaptivity components of the learning environment. In the second direction the participants have direct access to IA information supporting them to self regulate. Indicative works of the authors concerning interaction analysis include Fessakis et al (2004) for synchronous communication environments and Bratitsis & Dimitracopoulou (2008) for asynchronous.

This paper extend the work of Fessakis et al (2008) using a significantly larger number of groups that learn by design through blogging and focuses on the impact of graphical IA tools to the participants while they are collaborating. The main hypothesis tested in this work is that graphical synopses of the interaction raw data of the group blogging helps the group to increase the level of awareness and to regulate its function leading to better collaboration by students and moderation by teachers. In the followings the research conditions are explained along with the research questions and data collection tools, then the data are analyzed and interpreted and finally an overview discussion is provided.

Research Conditions

Aim of the present research is to explore the impact of IA graphs on the members of group blogs during collaboration. The main research question is therefore: **RQ:** *To what extent the interaction analysis graphs affects self-regulation of the group blog members? Are there any significant differences for impact among the different kinds of graphs?*

The experiment took place in the interval 19 FEB – 04 JUN of 2009. The participants were 147 students of the University of the Aegean in Greece, who were attended a course about the design and development of ICT applications in education. The majority of the students were at the third year while some of them at the second or forth. The age of the students is considered insignificant factor in this research since all of them are adults with similar education. Students were organized in 21 groups, 7 members each, using the list of their surnames in alphabetical order. For each group a blog was created in a popular free blogging service. The access to the blog content was private to the group members. Students attended three hours of training for familiarization with blogs at the beginning of the research. In addition, students had available on each blog a detailed manual of use. The students' task was to design technology enhanced lesson plans. The learning activity was structured according to the following phases: **Phase 1. Socialization:** Each student publishes a brief presentation of him/her and a short reflection on the lesson plans models; **Phase 2. First design and peer review:** Each student publishes on the blog the designs of 1-2 lesson plans and makes comments for the designs of the other members of the group; **Phase 3. Revision and peer review:** Each student revises the designs as many times his/her thinks necessary, taking into account the comments of his/her colleagues. Students continue also, the commenting of the others' designs and revisions; **Phase 4. Final project deliverable:** Finally students compile the deliverable for the project by selecting, after discussion, the best of their designs.

The groups were separated in three categories. The first category (K1-intragroup analysis) included the groups: (1, 2, 3, 7, 8 and 17). The researcher was supplying these groups with the IA graphs (A1-A4, figures 1-4) which are summarizing data for comparison of the group members according to their contribution on posting and commenting. In addition the groups of the category K1 had available social network analyses diagram (A5, figure 5) about who was commenting whom. The second category (K2 - inter-group analysis) included the groups: (10, 11 and 19). These groups were supplied by the researcher with IA graphs that was comparing the groups of this category to other groups in terms of total number of posts and comments (B1-B3, figures 6-8). The difference in the case of category K2 is that the members of each group are allowed to compare quantitative data of their group to other groups without reference to the individual contributions of members. The third category (K3 – Control groups) included the remaining groups and did not have available any IA graph. The posting of the graphs to the blogs has been scheduled to be done after completion of each main phase of the scenario. The graphs are presented in detail per group category in the next section.

The Interaction Analysis Graphs of the Research

The decision for the number and the kind of graphs has been done taking in consideration that most of the students were not experienced social software users either experienced graph readers. So the selected graphs are quite simple with the exception of the social network analysis diagram. The SNA diagram was included because students are using it also in other mandatory courses of the first year in the University.

Graphs for the Groups of Category K1

The interaction analysis graphs enabled students to retrieve information about the actions (including their own) of the members of their group. More specifically the graphs for category K1 groups were: **Graph A1:** Bar chart of the number of posts of each member per period and in total (Figure 3). **Graph A2:** Bar chart of the number of comments published by each member per period and in total (Figure 4). **Graph A3:** Bar chart of the number of comments received by each member per period and in total (Figure 5). **Graph A4:** Bubble chart for the number of posts and comments published by each member in total (Figure 6). The height of the bubble is proportional to the number of comments while the diameter is proportional to the number of posts. **Graph A5:** Social Network Analysis diagram (Figure 7). The nodes represent the students while the arcs show commenting.

Graphs for the Groups of Category K2

For the groups of the K2 category (10, 11, 19) the graphs were comparing the number of posts and comments of each such group to those of category K1 groups (1,2,3,7,8,17). More specifically the graphs in this case were: **Graph B1:** Bar chart for the number of posts of each group per period and totally (Figure 8). **Graph B2:** Bar chart for the number of comments of each group per period and totally (Figure 9). **Graph B3:** Bubble chart for the number of posts-comments for each group (Figure 10). The height of the bubble is proportional to the number of comments while the diameter is proportional to the number of posts.

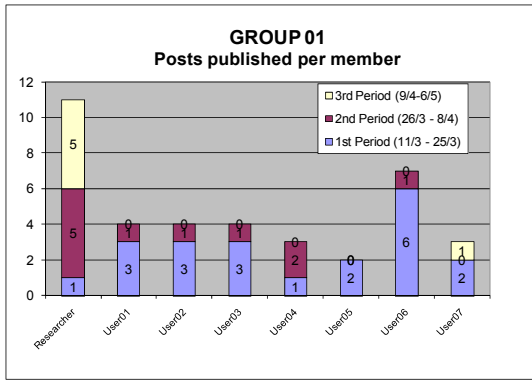


Figure 1. Graph A1.

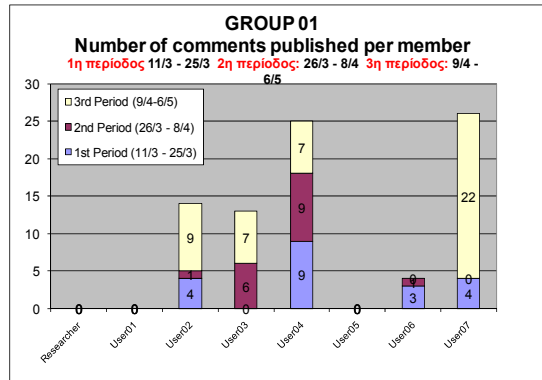


Figure 2. Graph A2.

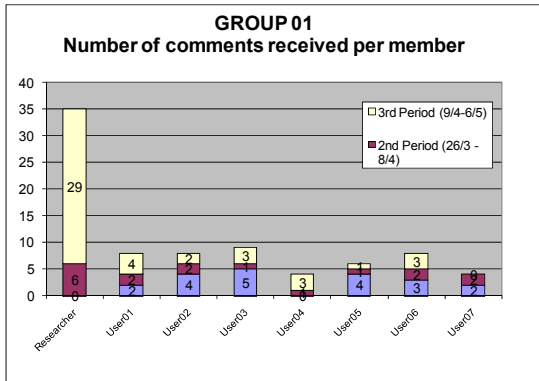


Figure 3. Graph A3.

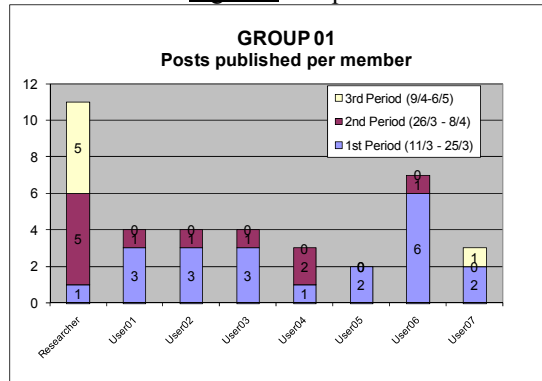


Figure 4. Graph A4.

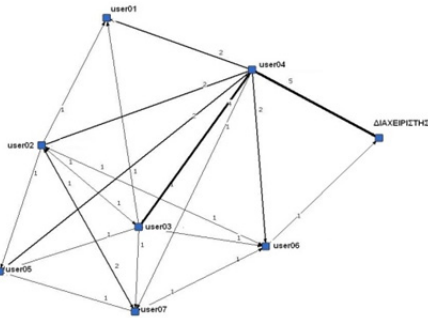


Figure 5. Graph A5.

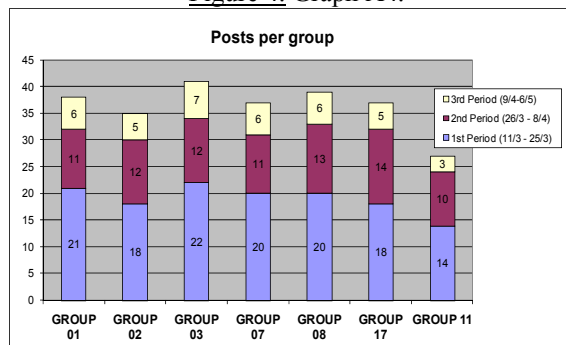


Figure 6. Graph B1.

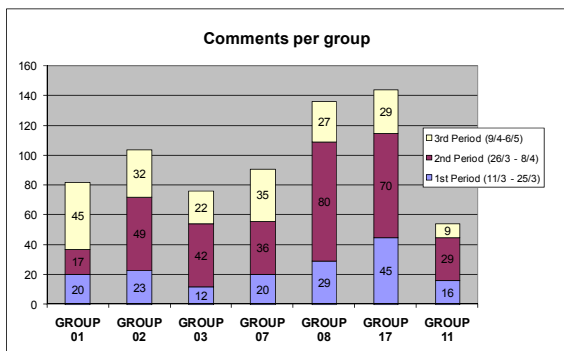


Figure 7. Graph B2.

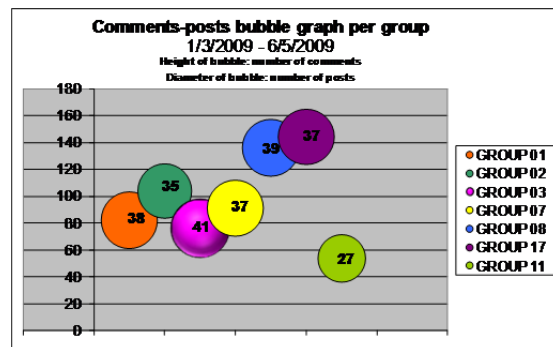


Figure 8. Graph B3.

Research Data Collection and Analysis

The raw data about the students' actions to the blogs were collected and analyzed. These data were used for the production of the interaction analysis graphs by a semi-automatic process. The students of the category K1 and K2 groups were asked to comment the posts with the graphs on their blogs in order to a) make sure that they had noticed the graphs and b) collect evidence about what information they decode from them. The analysis of the data is following.

RQ. *To what extent the interaction analysis graphs affects self-regulation of the group blog members? Are there any significant differences for impact among the different kinds of graphs?*

For this main research question we explore the impact of IA graphs to the groups of students collaborating through the blogs. For the comparison of the group categories we use: a) the mean number of posts and b) the mean number of comments published, per group for each category. The data collected from the blogs shows that the total number of actions for the 147 students was greater than 2095 (817 posts and 1278 comments). The comments of students to the graphs posts are not included in the calculation. Tables 1 and 2 summarize a separate variable for comments and posts for each group category. There are six variables of the form: KXC for comments and KXP for posts where X denotes the category of group (X in {1,2,3}). K1 and K2 categories are similar except to the kind of graphs they had available consequently any significant differences to the control groups' category K3 and among K1 and K2 could be related to the impact of the interaction analysis graphs.

In order to explore if there is any significant difference among the groups of the different categories we could apply ANOVA using the category (K) as a factor variable and the Comments (C) and Posts (P) variables as depended. For the ANOVA to be applicable there are specific prerequisites: the samples should be random and independent and the variances of the populations should be equal. In our case the samples are fairly random because of the use of alphabetical ordered surname list for the group formulation and in addition the samples are also independent because they have not common students.

Table 1. Basic statistics for the comments variables per groups category

Var	N	Min	Max	μ	σ
K1C	6	72	173	111.83	38.52
K2C	3	56	74	66.33	9.29
K3C	12	10	69	34.00	18.85

Table 2. Basic statistics for the posts variables per groups category

Var	N	Min	Max	μ	σ
K1P	6	40	57	49.33	6.41
K2P	3	39	53	45.33	7.09
K3P	12	0	47	32.08	8.68

Furthermore the distribution of the general populations are probably normal as the Shapiro-Wilk (S-W) normality suggests: (S-W_{K1C}=0.927; p=0.554, a=0.05), (S-W_{K3C}=0.937; p=0.461, a=0.05), (S-W_{K1P}=0.953; p=0.762, a=0.05) and (S-W_{K3P}=0.963; p=0.831, a=0.05). For the K2C and K2P normality it is not possible to apply a formal test because of the small number of groups (N<4) but we can hypothesise this taking a reasonable risk or override it using non parametric tests. The last prerequisite of ANOVA for the variance equality is checked using Levene's test. More specifically for the comments variables we have Levene's test (Median) (K1C-K3C)=4.141, df1=2, df2=18, p=0.033, a=0.05 thereafter the hypothesis *H0: The variances are identical* is rejected and the prerequisite is not fulfilled. In contrast, for the case of posts variables using the same test we have Levene's test (Median) (K1P-K3P)=0.411, df1=2, df2=18, p=0.669, a=0.05, consequently we have to accept hypothesis *H0: The variances are identical*. This is quite reasonable since the minimum number of posts was defined by the learning scenario and the students were not significantly differentiated. The above mean that for the case of comments variables we should use a non parametric test like Kruskal-Wallis while for the post variables it is possible to use ANOVA. So we have Kruskal-Wallis (K1C-K3C)=14.628, df=2, p=0.001, a=0.05 which means that we should reject *H0: The samples come from the same population*, and Kruskal-Wallis (K1P-K3P)=11.433, df=2, p=0.003, a=0.05 as well as for ANOVA(K1P-K3P) where F=10.586, sign.=0.001 < 0.05. All the tests show significant differences among comments and posts variables mean according to the group category factor.

At this point we will explore which pairs of variables have significant variables. We see that the groups of K1 category produce on average more posts and comments than the control groups of category K3 as well as from the groups of category K2 (significant differences on mean according to Mann-Whitney test for a=0.05). Furthermore groups of category K2 produced also more comments and posts on average than the control groups. Especially for the mean number of posts we have significant differences according to t-test only among K1P-K3P and K2P-K3P. The evidence of the research support the hypotheses that interaction analysis graphs had a positive impact to the intensity of group collaboration in terms of the number of posts and comments they produced. In addition the graphs for the category K1 (intragroup analysis) seem to have a stronger impact in terms of mean number of comments than those of category K2 (inter-group analysis). This could be happened because intragroup interaction analysis graphs compare the collaborators' contributions and increase the competition among the students in this way. The following excerpt from the comments of a member from group 8 for the graph A4 is revealing:

K.E. said: This graph constituted by circles showing how much a student deal with the group. And it seems that I am the least working member!!! I will agree with the other members of the group that this graph as well as the previous provides an incentive for me to try harder. 08 Apr 2009 10:19

Taking into account all the above we could hypothesize that the combined supply to the students with graphs of the both categories could be even more efficient in helping them to engage in collaboration and self regulate.

Discussion-Conclusion

The continuously increasing use of blogs in education and especially in the context of Computer Supported Collaborative Learning scenarios makes their systematic educational study more and more interesting. Blogs are quite easy to use by Students while they fulfill at a satisfactory level the communication and information management requirements of online collaborative learning by design scenario. The interaction analysis graphs of collaborating students could help teachers to monitor, moderate, coordinate, assess etc and students to increase their awareness and self regulate during their participation. The interaction analysis is also interesting for education researchers. The present research explores the impact of interaction analysis graphs organized in two categories. The first category includes: a) bar graphs and a bubble chart that summarize the evolution of the contribution in posts and comments for each group member separately, and b) a Social Network Analysis diagram with one node per students and arcs showing who was commenting whom. For each group the SNA depicts how extended and intensive was the communication (in term of comments) developed during collaboration, permitting the analysis of this communication for each pair of students. The graphs of the first category concern intra-group interaction analysis and aim to facilitate competition among the group members. The second category of graphs includes bar graphs and bubble chart summarizing the volume of posts and comments of whole groups permitting the comparison among groups. The graphs of the second category concern intergroup interaction analysis and aim to facilitate competition among the groups. From the experiment presented in the paper there is evidence for statistically significant differences among groups posts and comments production depending to the presence and the category of graphs. This means that interaction analysis graphs used has a significant impact on collaborative groups helping them to self-regulate during the learning scenario implementation. As far as the different categories of graphs is concerned (intra vs. inter group analysis), in this study the intra-group analysis graphs had a significantly stronger impact resulting in more active, productive and engaged groups with extensive commenting among their members. Interaction Analysis Graphs seem to give the students the feeling that teachers are monitoring their participation in the groups and this facilitates students to contribute and collaborate more.

The main weakness of this research is the small sample for the groups of category K2 which do not permits the secure generalization of the results for the graphs of the specific category. In contrast, the results for the comparison of interaction analysis graphs of category K1 to the control groups are fairly strong. Future directions of the research include the automatic production of the graphs and their smooth integration in the learning environment in order to give continuous access for the users and to be possible to collect interaction data of the students to the graphs.

References

- Allen, C. (2004). Tracing the evolution of social software, retrieved June 15, 2007 from: http://www.lifewithalacrity.com/2004/10/tracing_the_evo.html
- Bratitsis, T. & Dimitracopoulou, A. (2008). Interpretation Issues in Monitoring and Analyzing Group Interactions in Asynchronous Discussions. *International Journal of e-Collaboration*, IDEA Group Inc, 4(1), 20-40
- Blog. (2010). EduTech Wiki, A resource kit for educational technology teaching, practice and research. Retrieved 09:54, September 18, 2010 from <http://edutechwiki.unige.ch/mediawiki/index.php?title=Blog&oldid=28435>.
- Chen, H. L., Cannon, D. M., Gabrio, J., & Leifer, L. (2005, June). Using Wikis and Weblogs to Support Reflective Learning in an Introductory Engineering Design Course. Paper presented at the 2005 American Society for Engineering Education Annual Conference & Exposition, Portland, Oregon, retrieved June 15, 2007 from: http://riee.stevens.edu/fileadmin/riee/pdf/ASEE2005_Paper_Wikis_and_Weblogs.pdf
- Dimitracopoulou A. (2008). Computer based Interaction Analysis Supporting Self-regulation: Achievements and Prospects of an Emerging Research Direction, In Kinshuk, M.Spector, D.Sampson, P. Isaias (Guest editors). *Technology, Instruction, Cognition and Learning (TICL)*
- Downes, S. (2004, September/October). Educational blogging. *EDUCAUSE Review*, 14-26.
- Fesakis, G., Petrou, A., & Dimitracopoulou, A. (2004). Collaboration Activity Function: An Interaction Analysis Tool for Computer Supported Collaborative Learning Activities, *Advanced Learning Technologies*, IEEE International Conference on (pp. 196-200), *Fourth IEEE International Conference on Advanced Learning Technologies (ICALT'04)*, 2004
- Fessakis G., Dimitracopoulou A., Tatsis K. (2008), Supporting “Learning by Design” Activities Using Group Blogs, *Journal of Educational Technology and Society*. 1(4), 199-212
- Kim, B. (2001). Social constructivism. In Orey, M. (Ed.) *Emerging perspectives on learning, teaching, and technology*, retrieved June 15, 2007 from: <http://www.coe.uga.edu/epltt/SocialConstructivism.htm>
- Makri, K. & Kynigos, C. (2007). The Role of Blogs In Studying The Discourse And Social Practices of Mathematics Teachers. *Educational Technology & Society*, 10 (1), 73-84.

Video Analysis of Learners' Interactions with the Expert: Using Mobile Devices as Mediating Tools for Learning at a Museum

Susanna Mann, Peter Reimann, University of Sydney
Email: susanna.mann@sydney.edu.au, peter.reimann@sydney.edu.au

Abstract: This paper examines the interaction and communication of students with an expert at a museum using mobile devices as mediating tools for learning. In this study, the main focus of analysis using “focus shift and breakdown” is selected for detailed video-based interaction analysis. The five design factors for mobile learning are developed based on the analytic categories of five interesting situations from the video-recorded data. These design factors are (a) *Capturing* learning experiences, (b) *Acting* in the physical world, (c) *Interacting* with the expert, (d) *Collaborating* with learners, and (e) *Accessing* symbolic resources on the Internet. The purpose of building these design guidelines is to help educators and teachers design their mobile learning activities.

Introduction

The main purpose of this paper is to examine the communications and interactions of students with an expert at a museum using mobile devices as mediating tools to support the students' learning. A detailed video-based interaction analysis was conducted based on the selected video-recorded data. This video analysis may assist in understanding how learners interact with an expert at a museum using a mobile device as a mediating tool. This research study is part of the Australian Research Council (ARC) Linkage project, titled “Designing for Mobile Learning in a Technology Museum”, with the Powerhouse Museum (PHM) as the industry partner. The study adopts the Learning-By-Design (LBD) concept (Kolodner et al., 2003), and the learners are required to perform an exhibition design as part of their learning activities. The entire research project involves a thorough investigation on the effects of mobile devices on students' learning. However, this paper only reports the outcome of the video analysis of the learners' interactions with the expert at the museum using “focus shift and breakdown” analysis.

Learning-By-Design (LBD)

Kolodner et al. (2003) state that LBD emphasizes learning through hands-on design activities in which learners engage collaboratively in design activities and reflect on their experiences. LBD is a project-based inquiry approach rooted in *case-based reasoning (CBR)* and *problem-based learning (PBL)*. *CBR*, a constructivist model of learning, “refers to reasoning based on previous experiences (cases)”, whereas *PBL* is a cognitive-apprentice-style approach (Barrows, 1985; Krajcik & Blumenfeld, 2006) to educational practice such that “students learn by solving real-world problems and reflecting on their experiences” (Kolodner et al., 2003, p.501). An interesting finding from Kolodner et al. (2003) shows that LBD brings normal-achieving students to a level of capability usually found only among gifted students. It seems the LBD activities engage students to perform better because LBD gives students the opportunity to apply what they perceived and be appreciated for it. “Learning from design activities affords rich opportunities for learning.” (Puntambekar & Kolodner, 1998, p.35). Through this process of designing and manipulating the artefacts, individuals can construct and generate rich meaning (Piaget, 1954; Perkins, 1986). In this study, the learners' participation in their exhibition designs, using the concept of LBD with mobile devices as mediating tools, helped them think about their own learning throughout the whole design process.

Video and Interaction Analysis

Video analysis is a valuable analytic tool for studying learning activities in the real world. While video-based analysis is highly time-consuming, the video data provide a rich and high level of complexity of interaction such that the analysis is not only useful in terms of conversation, but also in terms of human interaction. *Interaction analysis* has been intensively used to analyse video data, as it allows researchers to analyse both conversations and interactions of individuals with other participants as well as with the artefacts in a physical environment. Video-based interaction analysis is a powerful tool to investigate human activity, particularly in complex, technology-mediated work settings and learning environments (Jordan and Henderson, 1995).

Foci of Analysis

Jordan and Henderson (1995) suggest the use of *foci of analysis* to analyse video records based on their many years of extensive ethnographic studies on the relationships between people and computers systems. Bøkdér (1996) outlines a technique for the mapping of use situations (1) that have been recorded on videotape using “focus shift and breakdowns” to analyse human-computer interaction. Bøkdér (1996) shows how “*focus shifts and breakdowns*” are instrumental in analysing human-computer interaction, and she outlines a technique for

the mapping of use situations that have been recorded on videotape. She further explains that *breakdowns* “related to the use process occur when work is interrupted by something”, and *focus shifts* are “a change of focus or object of the actions or activity that is more deliberate than those caused by breakdowns” (p. 150).

Participants

There were three participating groups: the MO-bile group (2), the Online group (2), and the Control group (2) involved voluntarily in this research project. Only the students in the MO-bile group had the opportunity to visit the museum using mobile devices (Tablet PCs) as mediating tools for learning. The other two groups used the online resources for their learning activities. Each group has six to seven students (all in Year 8) coming from different schools (private, local and selected government schools), with a mix of boys and girls. This paper focuses its investigation on the MO-bile group and the interaction of this group with the expert at the museum.

Method and Main Theme of Video-Based Interaction Analysis

The aim of this research is to understand how mobile devices affect learners; it emphasizes not only learners’ learning but also learners’ communication in an informal learning environment. The analysis of the entire research study includes a quasi-experimental study and an embedded single-case study. However, this paper only presents the study of the video-based analysis of the students interacting with the expert in a co-located learning environment in which they used mobile devices as their mediating tools for learning.

Students in the MO-bile group had an hour-long discussion with the expert (curator) about their final exhibition designs. The students’ final exhibition designs were captured on the Tablet PCs, and each student took his or her Tablet PC to discuss their own design with the expert at the PHM. No pre-set meeting structure was scheduled, and it was entirely up to the discretion of the expert to determine how this learning activity was to be delivered. The expert had all sorts of freedom to carry out the discussions and give advice to each student about his or her design at the exhibition space in “Cyberworlds”, the location where all 33 museum exhibits were selected and given to the students to help them design their exhibitions. Moreover, all of the students’ interactions with the expert using the Tablet PCs at the PHM (“Cyberworlds”) were video-recorded.

In working on the video analysis for this study, a combination of ethnography and interaction analysis methods was adopted. In the ethnographic context, some brief concurrent field notes were collected while videotaping so that some interesting instances could be notified and used for closer examination later.

As mentioned previously, a detailed analysis of an hour of video-recorded data is a complex matter. Instead of frame-by-frame transcription of an hour of video data (about the interaction of students with the expert, including verbal and non-verbal behaviours), a fragment of five interesting situations with a total of five minutes and twenty-five seconds in length was selected. The researcher viewed this fragment of video data over ten times in order to obtain a deep understanding of the phenomena related to the use of mobile devices by learners in an informal learning environment. This fragment of interesting sequences was selected for closer inspection through successive approximations. The analysis then proceeded with an identification according to the relevant analytic categories and careful transcription (the data from the videotapes was transcribed frame-by-frame in both verbal and non-verbal transcriptions) of sequences of activity related to a particular interest.

Accordingly, the relevant analytic categories were identified based on five interesting situations: (a) *Capturing* learning experiences (5), (b) *Acting* in the physical world, (c) *Interacting* with the expert, (d) *Collaborating* with learners, and (e) *Accessing* symbolic resources on the Internet. Five snapshots of five frames (in the format of 2D photos) representing five situations that were extracted from the video-recorded data are mapped into these five categories are shown in the first column of Table 1. The last column provides a detailed note explaining how the participants interacted with the expert. The focus of analysis of designing for mobile learning in an informal learning environment was based on these five categories. The analysis focused on the students’ non-verbal behaviour rather than their verbal conversation.

Result and Analysis using Focus shifts and Breakdowns

The main focus of analysis in this study is the “focus shifts and breakdowns” of the learning tasks and the use situations. In this study, the goal of using “focus shifts and breakdowns” to analyse of the mobile learning activities at the PHM intended to provide a deeper understanding of how the learners used the mobile devices as mediating tools for learning in an informal learning environment. This analysis was based on the selected fragment of video-recorded data emphasizing the MO-bile group students using mobile devices to interact with the expert at the PHM. The intention of this study is not to investigate the low-level interaction of the participants that involved detailed interaction analysis (such as gesture and facial expression) rather, it aims at the focus shifts of different use situations. The interesting situations mapped and analysed according to the “focus shifts and breakdowns” were suggested by Bødker (Bødker, 1996; Suchman & Trigg, 1991).

From an hour of video-recorded data, a fragment of five interesting situations (i.e. a total of five minutes and twenty-five seconds) of participants using their mobile devices at the museum was selected for detailed analysis, and then the actions of use situations were mapped. The focus shifts occurred from one action

of activities to another (i.e. from one “use situation” to another). The actions of the activities/situations can be categorised according to the five key ingredients for designing mobile learning in an informal learning environment.

Table 1 shows the “*focus shifts and breakdowns*” analysis of this study. Initially, the focus was on the action of situations concerning the student’s final exhibition design. The student’s exhibition design was **Captured** in the mobile device (Tablet PC) as was Student MG3’s interaction with the curator about her design with the help of this device [1]. However, as soon as Student MG3 realized that she had a query about a museum exhibit related to her design, she walked towards the other side of the exhibition space and the curator followed her, carrying her mobile device with him to the other end of the exhibition space. The focus shifted to another situation: Student MG3 and the curator both **Acted** in the physical world to clarify the queries by investigating the physical artefacts – museum exhibits using the mobile device [2]. While they were discussing the matter, another situation occurred. Another student, Student MG1, found something interesting and wanted to discuss it with Student MG3. She went to Student MG3 with her mobile device, and both students **Collaborated** with the help of the device [3]. After the students finished the collaboration, Student MG1 walked away with her mobile device. She realised that she needed more information about the museum exhibits, and then the focus shifted to another situation, as Student MG1 immediately **Accessed** the symbolic resources with her mobile device [4]. After Student MG1 finished her searching, she identified some queries that she wanted to put to the curator, so she went back to him. Another set of situations occurred, wherein Student MG1 and Student MG3 **Interacted** with the expert at the PHM with the help of their mobile devices [5].

Table 1 shows the details of this analysis with five 2D pictures representing the instances. The analysis of “focus shifts and breakdowns” with the five snapshots of five delineated photos is demonstrated in column 1 of Table 1. In column 2 is the mapping consisted of listing in one dimension – the action of situations/activities (i.e. *Capture*, *Act*, *Interact*, *Collaborate*, and *Access*) – that the participants focused on during the session (with reference to a snapshot for demonstration). Column 3 of the table shows the narrative of the situation, supplemented with the detailed explanation emphasizing their non-verbal behaviour (Bødker, 1996).

Discussion






The design artefact of the exhibition design provides a rich learning environment for students. With the mobile device as a mediating tool that captured the students’ exhibition designs, the students had the opportunity to explore and generate rich meanings, as they could easily *act* in the physical world (for example, at a museum), together with their own design artefact.

In this study, after students finished their final exhibition designs, they re-visited the museum where they were required to carry out a series of mobile learning activities at the museum. There, each student in the MO-bile group was provided with a Tablet PC, and all the students’ final exhibition designs were captured inside this device. Students could retrieve their own exhibition design at the PHM while discussing and interacting with the expert. They were also allowed to compare and view the other students’ exhibition designs. Furthermore, students had the opportunity to act in the physical world (at the museum), collaborate with their peers and interact with the expert regarding their exhibition designs. Students could also annotate and change their exhibition designs accordingly, and their new designs could be re-captured in their mobile devices. Thus, the Tablet PCs helped the students learn about the exhibits while touring at the museum.

The video data included a recording of Student MG3 walking spontaneously towards the other side of the exhibition space to further explore her queries about the museum exhibits of her exhibition design, and the expert followed her immediately, carrying along her mobile devices. This action, which was not planned, clearly indicated that the aspect of mobility provided by the mobile devices enabled the learners to act freely in an informal learning environment.

The important challenge of using mobile devices is to allow learners to be engaged in an activity that is mediated by the device. However, that action of activity does not hinder their experiences or force their attention onto the device itself, taking away their attention from the activity that should be supported (Vavoula et al., 2005). Some mobile learning projects that occurred with this problem are described below. The first example was the pilot trial for multimedia guides at the Tate Modern Museum in 2002 and 2003. This project did not function entirely as planned due to technical problems and the complicated interface of the PDAs that confused the visitors during their visits to the gallery/museum. Subsequent examples of the related problem were also found in studies of the Exploratorium (Fleck et al., 2002). To possibly avoid this problem, in this research study, the students’ final exhibition designs were captured in the Tablet PCs, and these devices were used as mediating tools to support their learning of the specific topic (i.e. “History of Computers”). Students spent weeks designing their exhibitions. They met the expert online and they all had a good impression of him. Therefore, when the students came to the museum, they were keen to meet the expert and discuss their designs further with him. This provided the opportunity for the students to construct and generate rich meanings (Piaget, 1954; Perkins, 1986; Puntambekar & Kolodner, 1998) about the museum exhibits by interacting with the expert, taking along their Tablet PCs at the museum. The mobile devices, using this setting in the museum context, can

Table 1: Understanding focus shifts and breakdowns using mobile device as a mediating tool at the Powerhouse Museum. [Source: Mann, 2010].

	<u>C</u>	<u>A</u>	<u>I</u>	<u>C</u>	<u>A</u>	<u>Details</u>
	1					<p><u>Exhibition design file is Captured in the mobile device</u> <i>C</i>: Looked attentively at the exhibition design displayed on the Tablet PC. <i>MG3</i>: Took over the stylus pen and used this pen to show the curator how to move around the exhibition room and clicked on the exhibition object to retrieve the text description of the museum object from the design file through the Tablet PC. <i>MG1</i>: Curator watched attentively how Student MG3 showed him to manipulate this design file.</p>
		2				<p><u>Student and expert Act in the PHM with the help of the mobile device</u> (Student MG3 tried to walk towards the other side to find out the museum exhibit that she did not understand, and curator followed her while still holding her Tablet PC) <i>MG3</i>: Looked at the museum exhibit while waiting for curator to come over and then showed the curator the museum exhibit that she did not understand. <i>C</i>: Curator bent down a little bit to see what the museum exhibit was that Student MG3 did not understand (at the exhibit object of the conductor). <i>C</i>: Curator used finger and pointed to the museum exhibit and explained to Student MG3 how it worked and then turned back, facing Student MG3. <i>MG3</i>: Looked attentively while curator was trying to explain to her.</p>
				3		<p><u>Students Collaborate with each other using the mobile device</u> <i>MG1</i>: Trying to walk towards Student MG3, carrying along with her Tablet PC, and she intended to show Student MG3 some interesting information on her Tablet PC. <i>MG3</i>: Turned her head to the right to meet Student MG1. <i>MG1</i>: Held up the Tablet PC and showed Student MG3 some interesting things, and she also collaborated with Student MG3 for a few seconds with a laugh before she walked away.</p>
					4	<p><u>Student Accesses extra symbolic resources using the mobile device</u> (At the back, curator still holding the Tablet PC and had a further discussion with Student MG3) Student MG1 was still inside the screen, and she was accessing the web resources using her Tablet PC for over 10 sec.</p>
			5			<p><u>Students Interact with the expert (curator) in Powerhouse Museum using mobile device as a mediating tool</u> <i>MG1</i>: Joined the conversation with the curator, and she also wanted to talk and show her information to the curator. <i>MG1</i>: Held up her Tablet PC and then looked at her design on the screen, and she intended to show her design to the curator. Curator also seemed interested to have a look. <i>MG3</i>: Continued the conversation with the curator. <i>MG1</i>: Curator listened attentively to what Student MG3 said, and Student MG1 also was trying to use the stylus pen to draw on the screen of the Tablet PC.</p>

Note: Numbers in orange color under the middle column of C A I C A [for example, 1,2,3,4,5] index the action of situations mainly focused on for the reference in the discussion; boldface and underline type shown in the last column are used to indicate a focus shift between use situations.

MG3: is Student MG3, *C*: is the expert at the PHM (i.e. the curator), and *MG1*: is Student MG1

act as mediating tools to assist students to engage in learning (to *act* in the physical world at the museum, to *interact* with the expert and to *collaborate* with their peers), but not to distract them away from the learning activity.

While there are many benefits of using the video-based interaction analysis to investigate the effects on learners with mobile devices, this analysis also has some drawbacks. Only a small number of students (in the MO-bile group) were involved in this detailed video analysis; therefore, the scalability may affect the generalisation. Moreover, there are other limitations in this video analysis because only one researcher and one transcription professional were involved in conducting the entire analysis. It would be useful to involve a local expert, such as the person on the tape, and have him or her attend the video review sessions. However, this was not possible, and it has not been done.

Conclusion

In this study, the learning activity of the exhibition design allowed the students to put real objects into practice (i.e. making use of the 2D museum exhibit pictures for students to design an exhibition). This exhibition design learning activity was further implemented in the informal learning settings with the help of the mobile devices.

In this study, the exhibition design (with the LBD concept) intended to create a rich learning environment for the students and make use of this learning activity with mobile devices to serve as mediating tools for student learning in an informal learning environment.

A good mobile learning design does not merely implement a set of mobile learning activities using mobile devices. Its success depends highly on whether its context can be set in a rich learning environment and particularly on whether the mobile devices can enhance the learners' ability to *Act* in the physical world, *Interact* with the expert, *Collaborate* with learners, and be able to *Access* symbolic resources wirelessly through the Internet (Mann & Reimann, 2007; Mann, 2008). The emphasis of this study is not so much on *Capturing* learners' experiences using mobile devices; rather emphasis is on the features of mobility of the device. The mobility provided by the mobile devices gives learners opportunities to *act* at the museum, *interact* with the expert, *collaborate* with peers and *access* extra Internet information on a specific topic with reference to their *captured* design artefacts (i.e. students' final exhibition design files). These five key ingredients were identified based on the detailed video-based interaction analysis. Further comparison of these five design factors with the other mobile learning exemplars were performed but this information has not been included in this paper.

As discussed above, the selection of video-based interaction analysis aims at using the theoretical concept of "focus shifts and breakdowns" and is driven by the design issue. The development of these five design factors is not focused on designing a mobile device itself, because that would require a deep level of understanding of the low-level interaction of participants (for example, gesture and facial expression). Rather, these design guidelines are based on the five design factors with five resource elements: device, expert, learners, exhibits and symbolic resources (on the Internet). The purpose of building these design guidelines is to help teachers and educators when designing their daily mobile learning activities for their students.

Endnotes

- (1) Use situations – a specific term used by Bødker (1996) in analysing and tracing the actual focus shifts in specific use situations. She outlines a technique for mapping use situations based on the video data.
- (2) MO-bile group has mobile and online settings, Online group has only the online setting, Control group has no treatment
- (3) "Capturing learning experiences" is the semantic shortcut for "Capturing the information of the students' activities (through the use of mobile devices) that contribute to their learning experiences".

References

- Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical year*. New York: Springer.
- Bødker, S. (1996). Applying activity theory to video analysis: How to make sense of video data in human-computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction*: MIT Press.
- Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., & Spasojevic, M. (2002). From informing to remembering: ubiquitous systems in interactive museums. *Pervasive Computing*, 1(2), 13-21.
- Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences*, 4(1), 39-103.
- Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., et al. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: putting learning by design into practice. *The journal of the learning sciences*, 12(4), 495-547.
- Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of The Learning Sciences*: Cambridge University Press.
- Mann, S. (2008). The emergence of mobile devices influencing learning from the viewpoint of convergences. In *Proceedings of Fifth IEEE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE2008)* (pp. 191-193): IEEE Computer Society.
- Mann, S. (2010). *Designing for mobile learning beyond online: Using mobile devices as mediating tools for informal learning in a technology museum*. Unpublished PhD Thesis, University of Sydney
- Mann, S., & Reimann, P. (2007). Mobile technology as a mediating tool for learning in the convergences from technology, collaboration, and curriculum perspectives. In *Proceedings of 6th International Conference of Mobile Learning, MLearn 2007* (pp. 151-155). Melbourne, 16-19 October 2007.
- Perkins, D. N. (1986). *Knowledge as design*. Hillsdale, NJ: Lawrence Erlbaum.
- Piaget, J. (1954). *The construction of reality in the child* (M. Cook, Trans), New York: Basic Books.
- Puntambekar, S., & Kolodner, J. L. (1998). Distributed scaffolding: Helping students learn in a 'Learning by design' environment. In A. S. Bruckman, M. Guzdial, J. L. Kolodner & R. A. (Eds.), *ICLS 1998, Proceedings International Conference of the Learning Sciences* (pp. 35-41).
- Suchman, L., & Triggs, R. H. (1991). Understanding practice: Video as a medium for reflection and design. In J. Greenbaum & M. Kyng (Eds.), *Design at work* (pp. 65-90). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Vavoula, G., Sharples, M., Scanlon, E., Lonsdale, P., & Jones, A. (2005). *Report on literature on mobile learning, science and collaborative activity* (No. D33.2.2): European Commission, DG INFSO, IST 507838.

Multiple Modes of Scaffolding to Enhance Web-based Inquiry

Annelies Raes, Tammy Schellens, Bram De Wever, Ellen Vanderhoven, Department of Educational Studies, Ghent University, Henri Dunantlaan 2, 9000 Ghent,
 Email: annelies.raes@ugent.be, tammy.schellens@ugent.be, bram.dewever@ugent.be, ellen.vanderhoven@ugent.be

Abstract: This study investigated the impact of different scaffolding conditions on students who are learning science through a web-based collaborative inquiry project. This project aimed to improve domain-specific knowledge, as well as strategy use on the internet, and metacognitive awareness. Three experimental conditions (human tutor as an external regulating agent, embedded question prompts (EQP), and both forms of support) were compared with a control condition. Findings revealed that providing students with EQP and a human tutor leads to significant higher performances comparing to the other conditions. Only with regard to strategy use and regulation of cognition, EQP alone is as effective as the condition with EQP and human tutor. Providing students with only a human tutor, however, didn't seem to provide enough help by itself, i.e. without incorporation of the embedded prompts. In this respect, our findings support the notion of multiple scaffolding as an approach to enhance web-based inquiry learning for a mix of students.

Theoretical Background

Scaffolding Web-based Inquiry

Science inquiry on the Web can be seen as a specific case of learning from multiple sources (Wiley et al., 2009). Although hypermedia learning is much more engaging, learning is also much more challenging (van Joolingen, de Jong, & Dimitrakopoulou, 2007). Strong regulation and metacognitive skills are needed (Azevedo, Moos, Greene, Winters, & Cronley, 2008; Bannert, 2009). Yet, previous research has shown that most students have poor self-regulatory skills and use ineffective strategies. These findings stress the need to effectively scaffold web-based inquiry processes.

The term scaffolding was traditionally introduced by Wood and colleagues (1976) in the context of one-on-one interactions in which the more knowledgeable adult tutors the child to complete a task that the child would be unable to do on his or her own. However, the modern classroom does not allow that privilege, since a teacher cannot interact with every child or every small group individually. Recent project-based learning approaches have therefore explored ways to use various forms of support provided by software tools (Davis & Miyake, 2004; Reiser, 2004). In the most common approach to computer-based support, both scripts and prompts can be embedded as scaffolds to individuals or small groups (Morris et al., 2009). However, because embedded tools that guide and support students through their inquiry processes cannot always include the dynamics of adult-child or even peer interactions, they also can be seen as limited. Embedded computer-based support is static which means that the amount and type of support is fixed and not adjusted based on an observation and a diagnosis of a learning (Puntambekar & Hubscher, 2005). Dynamic scaffolding on the other hand is based on observation and diagnosis and provides support in a personal way.

Consequently, recent studies claim that supporting multiple students in a classroom requires to rethink the notion of scaffolding. In this respect, the notion of distributed scaffolding with multiple modes of support is put forth as an approach to support inquiry learning in a classroom (McNeill & Krajcik, 2009; Puntambekar & Kolodner, 2005; Tabak, 2004). It is suggested that when support is distributed, integrated, and multiple, there are more opportunities for students to notice and take advantages of the environment's and activity's affordances (Puntambekar & Kolodner, 2005).

Multiple Modes of Scaffolding

Prompting

Prompting to support learning is gaining recognition as an important instructional method, and an increase in usage is most evident in the field of computer-based learning environments (Bannert, 2009). Prompts are defined as measures to induce and stimulate cognitive, metacognitive, motivational, and/or cooperative activities during learning, which vary from hints, suggestions, reminders, sentence openers or questions (Morris et al., 2009). Generally, they are based on the central assumption that students already possess some procedural knowledge about specific tasks, but do not recall or execute them spontaneously (Bannert, 2009). Previous research provides evidence that it is possible to improve individual learning in a technology environment, by implementing appropriate questioning strategies and reflection prompts that trigger students to activate their cognitive processes (Demetriadis, Papadopoulos, Stamelos, & Fischer, 2008). However, studies have found that

simply prompting students to use strategies is not enough to lead to improvements in learning outcomes and web literacy (Lazonder & Rouet, 2008; Stadler & Bromme, 2007). Learners may need further support to take advantage of the opportunity to self-regulate their performance, e.g. by means of distributed monitoring (Wecker, Kollar, & Fisher, 2010) or human guidance (Azevedo et al., 2008). Therefore, the current study also takes into account a second mode of support.

Human Tutor

Providing students with an external regulating agent, i.e. teacher or a human tutor, is another method for improving learning outcomes and students' regulation of their web-based learning (Azevedo & Hadwin, 2005; Azevedo et al., 2008). This method is proved to be more beneficial than when students only need to self-regulate their learning (Azevedo et al., 2008). In this case, the teacher/human tutor acts as an adaptive scaffold that facilitate students' web inquiry by prompting students to deploy certain key processes and strategies during web-based learning.

Research Questions

Accordingly, this study focused on the following research questions:

1. What are the effects of different scaffolding conditions on students' *domain-specific knowledge*?
2. How do different scaffolding conditions influence learner's *strategy use* on the web?
3. Do different scaffolding conditions influence learners' *metacognitive awareness*?

Method

Participants and Design

During a four-week field study, students had to work in pairs on an inquiry based science project about climate change (for a description of context and project see Raes, Schellens, & De Wever, 2010). The project was designed in partnership with science teachers and in accordance with the Knowledge Integration framework (Slotta & Linn, 2009). The total project consisted of four main inquiry learning activities spread over 4 sessions of 50 minutes each. Pretest-posttest differences in students' domain-specific knowledge, strategy use and metacognitive awareness were measured. The participants in this study were 347 students from 18 secondary school classes, grade 9 and 10 from 10 Flemish secondary schools. The classes were randomly distributed over the 4 conditions. Three experimental conditions were compared with a control condition in a two-by-two factorial quasi-experimental design (see Figure 1). The conditions differed in the provided type and amount of scaffolding during online inquiry.

		HUMAN TUTOR AS AN EXTERNAL REGULATING AGENT	
		Present	Absent
EMBEDDED QUESTION PROMPTS	Present	Condition 1: human tutor and embedded question prompts (EQP) N = 101 from 5 classes	Condition 2: embedded question prompts (EQP) N = 72 from 4 classes
	Absent	Condition 3: human tutor N = 97 from 5 classes	Condition 4: no scaffolds N = 63 from 4 classes

Figure 1. Quasi-experimental 2 x 2 Factorial Design.

Measurements

The pre and post achievement test consisted of eight assessment items, 4 open-ended knowledge questions and 4 multiple-choice items, in which students were asked for explanation. To measure students' strategy use, they were faced with a scientific controversy. They were asked to take a stand and justify their position with appropriate evidence from the web. Students were asked to describe in detail their strategy for searching for

evidence and formulating their position. Finally metacognitive awareness was measured by means of an adapted version of the Metacognitive Awareness Inventory (Schraw & Dennison, 1994), which supports the two-component view of metacognition, i.e. knowledge about cognition and regulation of cognition.

Statistical Analysis

ANCOVA's were conducted with posttest scores as dependent variable, Condition as independent factor, and pretest scores as covariate to discover whether there are differences between conditions on the posttest measure, after adjustment for the pretest scores. The Bonferroni test, which corrects for the number of pairwise tests, was used to compare main effects. The significance level was set up to 5% for all analyses.

Results

RQ 1: Effects of Different Scaffolding Conditions on Students' Domain-specific Knowledge

An overall increase is found with respect to students' domain-specific knowledge about climate issues. Students from the condition with multiple scaffolds made the highest learning gain. ANCOVA confirms that the four conditions significantly differ on the adjusted means ($F(3,332) = 12.592, p < .001$). Pairwise comparisons (see Table 1) shows that students in condition 1 (EQP + Human Tutor) significantly outperform students from the conditions 2 and 3 with a single mode of support as well as students from condition 4 (no scaffolds). These three conditions, however, do not significantly differ from each other.

Table 1: Pairwise comparisons for domain-specific knowledge as dependent variable.

Condition (I)	Condition (J)	Mean Difference (I-J)	SE	p^a
1 EQP + Human Tutor	2 EQP	2.15*	0.57	.002
	3 Human Tutor	3.23*	0.55	<.001
	4 No scaffolds	2.55*	0.61	<.001
2 EQP	1 EQP + Human Tutor	-2.15*	0.59	.002
	3 Human Tutor	1.08	0.58	.380
	4 No scaffolds	0.40	0.65	1.000
3 Human Tutor	1 EQP + Human Tutor	-3.23*	0.55	<.001
	2 EQP	-1.08	0.58	.380
	4 No scaffolds	-0.68	0.61	1.000
4 No scaffolds	1 EQP + Human Tutor	-2.55*	0.61	<.001
	2 EQP	-0.40	0.65	1.000
	3 Human Tutor	0.68	0.61	1.000

^a Adjustment for multiple comparisons: Bonferroni

* $p < .05$

RQ 2: How Do Different Scaffolding Conditions Influence Learner's IPS Skills

Regarding strategy use, students reported to conduct more strategies during their online search in the posttest. This increase was found in all conditions, however, students in condition 2 (EQP) realize the highest learning gain compared to the other conditions. ANCOVA revealed that the four conditions do not significantly differ on the posttest measure, after adjustment for the pretest scores ($F(3,325) = 0.495, p = .686$).

RQ 3: Do Different Scaffolding Conditions Influence Learners' Metacognitive Awareness?

Knowledge about Cognition

Concerning the scale *knowledge about cognition* which measures an awareness of one's strengths and weaknesses, knowledge about strategies and why and when to use those strategies, students from the four conditions did not significantly differ from each other on the pretest. After the intervention, however, all students reported a higher knowledge of cognition and conditions do significantly differ on the posttest adjusted means ($F(3,321) = 4.361, p = .005$).

Pairwise comparisons (see Table 2) shows a significant difference between condition 1 (EQP + Human Tutor) and condition 4 (no scaffolds). Condition 1 also differs from conditions 2 and 3, but the differences are not significant. The differences between conditions 2, 3 and 4 are minimal.

Table 2: Pairwise comparisons for knowledge about cognition as dependent variable.

Condition (I)	Condition (J)	Mean Difference (I-J)	SE	p^a
1 EQP + Human Tutor	2 EQP	0.11	0.05	.133
	3 Human Tutor	0.11	0.04	.071
	4 No scaffolds	0.17*	0.05	.006
2 EQP	1 EQP + Human Tutor	-0.11	0.05	.133
	3 Human Tutor	0.01	0.05	1.000
	4 No scaffolds	0.06	0.05	1.000
3 Human Tutor	1EQT + Human Tutor	-0.11	0.04	.071
	2 EQP	-0.01	0.05	1.000
	4 No scaffolds	0.06	0.05	1.000
4 No scaffolds	1 EQT + Human Tutor	-0.17*	0.05	.006
	2 EQP	-0.06	0.05	1.000
	3 Human Tutor	-0.06	0.05	1.000

a Adjustment for multiple comparisons: Bonferroni

* $p < .05$

Regulation of Cognition

Concerning the scale *regulation of cognition* which measures a number of sub processes that facilitates the control aspect of learning, i.e. planning, information management, comprehension monitoring, and evaluation, all students report to perform more regulation after the intervention than before. Particularly, the condition with multiple scaffolds and the condition with EQP realize a high learning gain.

The four conditions do significantly differ on the posttest measure, after adjustment for the pretest scores ($F(3,321) = 5.702, p = .001$). Pairwise comparisons (see Table 3) show that the difference between condition 1 (EQP + Human Tutor) and 2 (EQP) is negligible. Both EQP conditions do however differ significantly from the control condition (no scaffolds). No significant differences are found between condition 3 (Human Tutor) and the other conditions.

Table 3: Pairwise comparisons for regulation of cognition as dependent variable.

Condition (I)	Condition (J)	Mean Difference (I-J)	SE	p^a
1 EQP + Human Tutor	2 EQP	-0.02	0.06	1.000
	3 Human Tutor	0.11	0.05	.210
	4 No scaffolds	0.20*	0.06	.004
2 EQP	1 EQP + Human Tutor	0.02	0.06	1.000
	3 Human Tutor	0.13	0.06	.158
	4 No scaffolds	0.22*	0.06	.004
3 Human Tutor	1EQT + Human Tutor	-0.11	0.05	.210
	2 EQP	-0.13	0.06	.158
	4 No scaffolds	0.10	0.06	.696
4 No scaffolds	1 EQT + Human Tutor	-0.20*	0.06	.004
	2 EQP	-0.22*	0.06	.004
	3 Human Tutor	-0.10	0.06	.696

a Adjustment for multiple comparisons: Bonferroni

* $p < .05$

Discussion

Our results indicate that learning science by means of a web-based inquiry project is effective to enhance learners' knowledge construction and to enhance their strategy use and metacognitive awareness. We can conclude this based on evidence for an overall increase in students' performances. However, pairwise comparisons show that benefits significantly differ based on the scaffolds students are provided with. Providing students with embedded question prompts and a human tutor whose role is to facilitate the use of online search strategies and self-regulatory processes leads to statistically significant higher performances compared to the other conditions. Providing students with only embedded question prompts is as effective as the condition with EQP and human tutor with regard to regulation of cognition and strategy use. Providing students with a human tutor but without incorporation of the embedded prompts, however, does not provide enough help. In this respect, our findings support the notion of multiple, distributed scaffolding (Puntambekar & Kolodner, 2005; Tabak, 2004) as an approach to enhance web-based inquiry learning in complex classroom environments and are in line with previous research (McNeill & Krajcik, 2009).

However, a limitation of the present study is that strategy use during web inquiry was measured by means of self-report. Additional research is needed to get more insight in the strategies students are using. Further research will make use of thinking aloud protocols (Azevedo et al., 2008) and logfile recording (Perry & Winne, 2006) in order to find out in more detail how students actually perform the metacognitive and strategic learning activities during web-based collaborative inquiry. Given the fact that not all dyads collaborate in the same way and this might have an effect on the regulation of the search task (Lazonder & Rouet, 2008), future research could also pay more attention to the collaboration processes that are inherent to the research design and approach of this study.

References

- Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition - Implications for the design of computer-based scaffolds. *Instructional Science*, *33*, 367-379.
- Azevedo, R., Moos, D. C., Greene, J. A., Winters, F. I., & Cromley, J. G. (2008). Why is externally-facilitated regulated learning more effective than self-regulated learning with hypermedia? *Educational Technology Research and Development*, *56*(1), 45-72.
- Bannert, M. (2009). Promoting Self-Regulated Learning Through Prompts. *Zeitschrift Fur Padagogische Psychologie*, *23*(2), 139-145.
- Davis, E. A., & Miyake, N. (2004). Explorations of scaffolding in complex classroom systems. *Journal of the Learning Sciences*, *13*(3), 265-272.
- Demetriadis, S. N., Papadopoulos, P. M., Stamelos, I. G., & Fischer, F. (2008). The effect of scaffolding students' context-generating cognitive activity in technology-enhanced case-based learning. *Computers & Education*, *51*(2), 939-954.
- Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*(3), 287-312.
- Lazonder, A. W., & Rouet, J. F. (2008). Information problem solving instruction: Some cognitive and metacognitive issues. *Computers in Human Behavior*, *24*(3), 753-765.
- McNeill, K. L., & Krajcik, J. (2009). Synergy Between Teacher Practices and Curricular Scaffolds to Support Students in Using Domain-Specific and Domain-General Knowledge in Writing Arguments to Explain Phenomena. *Journal of the Learning Sciences*, *18*(3), 416-460.
- Morris, R., Hadwin, A. F., Gress, C. L. Z., Miller, M., Fior, M., Church, H., et al. (2009). Designing roles, scripts, and prompts to support CSCL in gStudy. *Computers in Human Behavior*, *In Press*, Corrected Proof.
- Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist*, *40*(1), 1-12.
- Puntambekar, S., & Kolodner, J. L. (2005). Toward implementing distributed scaffolding: Helping students learn science from design. *Journal of Research in Science Teaching*, *42*(2), 185-217.
- Raes, A. M. L., Schellens, T., & De Wever, B. (2010). *The impact of web-based collaborative inquiry for science learning in secondary education*. Paper presented at the Interantional Conference of the Learning Sciences, Chicago, IL.
- Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *Journal of the Learning Sciences*, *13*(3), 273-304.
- Slotta, J. D., & Linn, M. C. (2009). *WISE Science, Web-Based Inquiry in the Classroom*. New York: Teachers College Press.
- Stadtler, M., & Bromme, R. (2007). Dealing with multiple documents on the WWW: the role of metacognition in the formation of documents models. *Computer-Supported Collaborative Learning*, *2*, 190-210.
- van Joolingen, W. R., de Jong, T., & Dimitrakopoulou, A. (2007). Issues in computer supported inquiry learning in science. *Journal of Computer Assisted Learning*, *23*(2), 111-119.
- Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Contemporary Educational Psychology*, *19*(4), 460-475.
- Tabak, I. (2004). Synergy: A complement to emerging patterns of distributed scaffolding. *Journal of the Learning Sciences*, *13*(3), 305-335.
- Wecker, C., Kollar, I., & Fischer, F. (2010). *Fostering Online Search Competence and Domain-Specific Knowledge in Inquiry Classrooms: Effects of Continuous and Fading Collaboration Scripts*. Paper presented at the Interantional Conference of the Learning Sciences, Chicago, IL.
- Wiley, J., Goldman, S. R., Graesser, A. C., Sanchez, C. A., Ash, I. K., & Hemmerich, J. A. (2009). Source Evaluation, Comprehension, and Learning in Internet Science Inquiry Tasks. *American Educational Research Journal*, *46*(4), 1060-1106.
- Wood, D., Bruner, J. S., & Ross, G. (1976). Role of Tutoring in Problem-Solving. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *17*(2), 89-100.

Social Annotating in the Online Margins: (Re)designing an Annotation Tool Drawing on Unintended Ways University Students and Faculty Chose to Use It

Bures, E.M., Bishop's University, Lennoxville, Quebec, ebures@ubishops.ca

Feenberg, A., Simon Fraser University, Vancouver, Canada, afeenberg@sfu.ca

Xin, C., Simon Fraser University, Vancouver, Canada, cxin@sfu.ca

Abrami, P. C., Concordia University, Montreal, Quebec, pabrami@education.concordia.ca

Abstract: This study explores a feature that allows one to highlight parts of online messages and comment in the margins. Data comes from 12 university-level courses in 3 universities, n=198 students and n=5 instructors. A videotaped group discussion, a survey, and annotation usage were analyzed. The tool was designed to facilitate retrieval and reviewing. Students actually used the tool more collaboratively, akin to a Web 2.0 tool. Students perceived seven benefits (in decreasing frequency): insight into thoughts of others, instructor feedback, critical understanding, text-review, group processes, emphasizing relevance, and insight into others' thoughts about one's message. Fourteen uses within four categories were identified: retrieval only (i.e. using keywords); reflection (i.e. elaborating on a point); replying (i.e. directly responding to author of message or of an annotation), and instructor feedback. Replying and instructor feedback were unanticipated. We made the default for annotations public and increased annotations' word-limit to address emergent uses.

Objectives

Research evidence from many learning and epistemological perspectives suggests the efficacy of learning through dialogue, from Socrates to Vygotsky. In online dialogue students and teachers are able to leave and re-read electronic messages for each other at any time, sustaining ideally more reflective dialogue than possible face-to-face as participants can think about their contributions and those of others with more care. Despite potential benefits of learning online, online dialogue (much like face-to-face conversations) can engage students in surface learning. This study explores an annotation feature embedded into software to support users' cognitive processes. In face-to-face discussions furniture is arranged in various ways to induce dialogue; an empty room with no furniture would not seem likely to promote a good discussion. Similarly, features embedded into software (such as highlighting, annotating and labelling) may promote better discussions.

Literature Review

Human interaction through text based discussion forums is widely employed in online education today. Over the past two decades, many researchers have written about the pedagogical potential of forums for reflection, critical thinking, and collaborative learning. Many hoped that the additional time to peruse online messages would promote critical thinking (cf. Scardamalia & Bereiter, 1994), yet critical thinking is not always evident in online dialogue and sustaining meaningful dialogue is challenging. A number of recent studies have found that there is a lack of deep engagement, and that students do not view forums as a space for critical discourse (Friesen, 2009; Garrison, Anderson, & Archer, 2000; Lee & Jeong, 2009; Osman & Duffy, 2009; Rourke & Kanuka, 2007; Wise, Duffy, & Padmanabhan, 2008). Online, the very wait-time between writing, reading, and responding which allows for deeper thinking also poses challenges. The sheer number of messages, in addition to the various message branches, can overwhelm the learner (Hewitt, Brett & Peters, 2007), who cannot discern what to read and in what order, much less where to post or what to post about (Rohfeld & Hiemstra, 1995; Wise, Duffy, & Padmanabhan, 2008).

To support learning, online discussion environments must structure interactions to encourage productive collaboration (Dillenbourg, 2002; Suthers, 2007). Some have argued that web forums support divergent thinking, and hence convergent thinking needs to be supported by the moderator, the assignments, and/or the interface itself (i.e. Harasim, 1993). Software should be mindfully developed to support healthy online behaviors that initiate, sustain, and advance dialogue (Xin & Feenberg, 2006). Unfortunately, widely-used forums, such as those in course management systems like WebCT, Blackboard, and Moodle, are little different from those used in the early days of web-based course management systems. Indeed, apart from cosmetic changes, most current forum interfaces are quite similar to the original newsgroup programs from which they descend. Some pedagogically advanced systems have been developed, such as Knowledge Forum (Scardamalia & Bereiter, 1993), and TextWeaver (Feenberg & Xin, 2003), but thus far they have not succeeded in entering the mainstream. One approach is to develop open-source extensions to open-source web-based softwares such as Moodle in order to put clothes on them, to allow the pedagogical dressing of them.

Marginalia was developed (Marginalia, 2009) as an open source extension to Moodle. It adds several

key features to help structure dialogue and encourage healthy online behaviors. The core functionality is an annotation feature: the capability to highlight passages of text in forum posts and write short notes in the margin next to them, just as the reader of a book might underline passages and scribble notes in the margin. A number of studies have found annotation helpful for online learning (Bateman, Brooks, Mccalla & Brusilovsky, 2007; Farzan & Brusilovsky, 2008; Huang, Huang & Hsieh, 2008; Kaplan & Chisik, 2005; Lee & Calandra, 2004). This research involves reiteratively designing the tool to match users' needs.

Research Questions

This paper focuses on the design and analysis stage of the research. The key questions are:

- 1) What benefits of the annotation tool do students perceive?
- 2) In what ways (intended and unintended) do students use the annotation tool?
- 3) Based on the actual uses of the annotation tool, what changes to the tool should be made?

Research Methods

The approach falls within the design experiment literature (cf. Brown, A., 1992; Reeves, Herrington, & Oliver, 2005). The tool is designed concomitantly to research being conducted. This study involves formatively evaluating and (re)designing the annotation feature. Open-ended coding procedures are used to categorize perceived student benefits and actual uses of the tool.

The participants come from 12 intact classes, 5 from a small rural Quebec undergraduate university, 5 from a large Western University, and 2 from a small rural Western university, n=198. Five instructors are involved. In 9 of the courses the feature was introduced during an online activity of a minimum of 2 weeks duration and students were able to use it as they chose; in 3 cases the use of the feature was a single class-time (n=68).

Data sources include a video-taped group discussion, a survey with open-ended questions about the benefits and uses of the tool, and annotations.

The feature allows one to highlight parts of messages and append margin notes. One can see one's own annotations, public annotations made by other people, and a summary of annotations. See Figure 1.

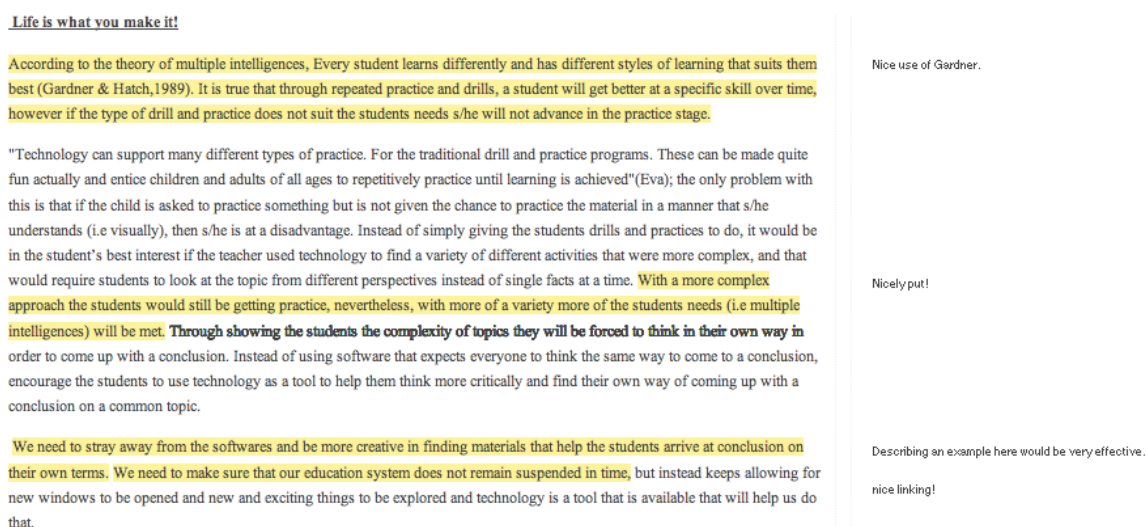


Figure 1. The Highlighting and Annotating Feature.

Results and Discussion

Students' Perceptions of Potential Benefits of Annotation Feature

In the video-footage students from an intact classroom (n=24) discussed the feature's potential following a class activity using it. The key points made by students were summarized by the first author and a research assistant. The students emphasized benefits not originally envisioned such as receiving formative feedback from the teacher and peers, and being able to make side comments about the task. They also saw its utility to further their understanding of course material. Student perceptions of the feature's potential as discussed in the video influenced how the feature was used in future courses especially to comment on students' online dialogues. Overall, students were positive about the annotation tool, despite some technical difficulties.

Students' responses to open-ended items on the survey were coded and categorized using an open-coding procedure to identify seven key benefits in decreasing frequency: insight into thoughts of others, instructor feedback, critical understanding, review text, supporting group processes, emphasizing relevance, and

insight into what others think of what one writes. See Table 1. Originally conceived as a tool to help students review and re-read online dialogue, it was essentially a review tool. Perusing Table 1 demonstrates a different potential that emerged through its use in a range of pedagogical contexts. Surprisingly, the most frequent benefit that students mentioned is being able to have insight into the thoughts of others by reading their annotations.

Table 1: Student perception of key benefits of highlighting and annotation feature.

Key Benefits	
Insight into thoughts of others	Steve wrote: "I thought was useful for finding out what the teacher and peers thought about a given subject."
Instructor feedback	Formal assessment: The tool makes it easy for the instructor to give feedback to students by highlighting pieces of the text and making comments. "It helped for sure. It was easy to read Eva's comments and easier to understand them. It also look very clean and neat."
Critical understanding	"It made me more aware of different perspectives on using technology as well as different teaching approaches." "When I read online I sometimes don't really read, but by being able to make comments, I actually read well and understand more."
Review text	Students can highlight pieces to put into a portfolio or a final summary. "It helps the students go back and review their work."
Group processes	The feature can be useful to track the group process.
Emphasizing relevance	Some students felt it focused them on the most relevant information. "Cool to use with a group to get the most information (relevant)."
Insight into what others think of what one writes	Students reported liking to read what others think about what they have written; some were especially interested in the instructor's perceptions.

How Students and Instructors Used the Feature

Looking at the actual usage of the tool demonstrates more unanticipated potential. Students used Marginalia in 12 courses. $N=198$ students contributed 2067 messages and 1605 highlights/annotations, $M=10.44$ and 8.11 respectively. Fifty-one percent of students used the feature. We summarized four distinct functions of the tool: retrieval only; reflection; reply; and instructor feedback (see Table 2). Retrieval only annotations include highlights without any annotations and keywords, which make it easy to return to those passages. Reflection annotations also facilitate retrieval, but they add to the highlighted passage by summarizing what was said or by making connections to other ideas. The third function was replying. Unexpectedly, students actually created dialogues on the side of messages where they responded to each other's annotations. See Figure 2. This use of annotations or meta-narrative shows the students responding to each other's annotations! The fourth function was that instructors provided summative and formative feedback.

<p>One student writes: <i>However, through experience I have found that some students when they are writing their posts are not clear in their writing.</i></p> <p>This is annotated by several people who respond to each other's annotations:</p> <p>Jade: I believe people are equally unclear when they speak. It is just easier to get away with in person because you are given the ability repeat your point several times.</p> <p>Jade: People also use words that not everyone is familiar with, not to mention all sorts of slang and jargon when they are speaking face-to-face.</p> <p>John: This can be dissuaded by using a rubric the explicitly 'punishes' it.</p> <p>Amy: this is very problematic in online group discussions and what happens is that often other members can become offended by the strength of the text.</p>

Figure 2. Example of Using Annotation Feature to Hold a Dialogue in the Margins.

Iterative open-coding of the annotations was conducted. Twelve student uses and two instructor uses of the feature were identified within the categorization of four broad functions. See Table 2.

Table 2: Four functions of the annotation feature.

Function	Description	Examples Found
Retrieval Only	<ul style="list-style-type: none"> These annotations facilitate easily retrieval, signifying information or ideas that are worth following up on later 	keywords; highlighting only
Reflection	<ul style="list-style-type: none"> Similar to retrieval only, these annotations will facilitate retrieval of significant information. But in addition students using these annotations appear to be deepening their understanding. 	critical understanding; reinforcing understanding; synthesizing; questioning
Reply	<ul style="list-style-type: none"> These annotations directly communicate a message, such as a question, an agreement or disagreement, or a short answer to a question, to the author of the original message or of another annotation referring to the message. 	encouraging; agreeing; motivating help progress through task content dialogue in margins; questioning directly
Instructor feedback	These annotations are provided by instructor and depend in part on the type of activity.	Informal feedback Formal feedback at end

Summary of Changes Made to the Annotation Tool Reflecting Emergent Uses

Reflecting the uses we witnessed students and instructors make of the annotation tool, some adjustments were made. Given the type of enthusiasm we saw generated around reading other people's annotations, the default of the annotations was made public rather than private. Other major decisions revolved around the way students used the annotations to hold dialogues in the margins. A button was added to allow the user to comment on an annotation, which would then post a new message. This was an important controversial design decision, with some members of the team thinking it was beneficial to group processes that students were using the feature to hold a dialogue in the margins, and others pointing out the negatives especially possible cognitive overload as learners wonder where to read. The 'reply to this annotation' button was a compromise. We also increased the length of annotations to 250 words. Competing visions of what Marginalia should be emerged; originally marginal notes were not intended to create a separate channel of dialogue but instead were designed to support the private enterprise of reviewing messages. If the conversation in the margins becomes the main conversation this could make it hard to find the key relevance, undermining the main goals of the tool. Still, the way the tool was actually used was far beyond the original design of privately reviewing messages; students were able to share their annotations with potential learning benefits and made it primarily a social enterprise, akin to a Web 2.0 tool. Should we then limit their use of annotations as a separate channel of communication?

Issues are still being resolved. The limit of 250 words was problematic for students and instructors. The 'reply to annotation' button returning students to the main dialogue to reply to an annotation is frequently ignored and it might be better to keep a thread running in the margins in some circumstances such as when the instructor is providing feedback or students are engaging in a meta-cognitive discussion about the task.

Conclusions

Students used the annotation tool in a range of ways, from reviewing messages for later (which was very much in keeping with the design), to keeping track of the class task (who is doing what) and even to emotively (or otherwise) respond to one another without actually replying to the message as a whole. Students emphasized the benefit of seeing the annotations of their instructors and peers. The range of uses was well beyond what was originally envisioned in the design, and we have made alterations to sustain students' wishes for the tool within reason, making a review tool into a collaborative tool. Still, some design decisions controversially constrain the use of annotations to make it difficult to create a separate dialogue in the margins.

The enthusiasm shown for the feature was astonishing especially when compared to the lack of enthusiasm for other knowledge tools to scaffold online learning (Bures, Abrami & Schmid, 2010). On the other hand, although students reported appreciating the annotations of others, many students never used the feature. Guided, focused and purposeful interaction goes beyond whether opportunities for interaction exist to consider especially why and how interaction occurs. Several evidence-based approaches may be useful in the next generation of Marginalia to facilitate more purposeful interaction drawing on theories of self-regulation, multimedia learning, motivation, and collaborative learning (Abrami, Bernard, Bures, Borokhovski, & Tamim, 2011). As these features become increasingly common, it becomes increasingly important to design them to support students' learning and dialogue and avoid unnecessarily adding cognitive load (Dillenbourg, 2002; Stahl, 2006).

References

- Abrami, P. C., Bernard, R. M., Bures, E. M., Borokhovski, E. & Tamim, R. (in press). Interaction in distance education and online learning: Using evidence and theory to improve practice. *Journal of Computing in Higher Education* (special issue).
- Bateman, S., Brooks, C., Mccalla, G., and Brusilovsky, P. (2007). Applying collaborative tagging to e-learning. In Proceedings of the 16th International World Wide Web Conference (WWW2007).
- Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141-178.
- Bures, E. M., Abrami, P. C., & Schmid, R. F. (2010). Exploring whether students' use of labelling depends upon the type of online activity. *International Journal of Computer-Supported Collaborative Learning*, 5(1), 103-116.
- Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P.A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL?* (pp. 61-91). Heerlen: Open Universiteit Nederland.
- Farzan, R. and Brusilovsky, P. (2008). Annotated: A social navigation and annotation service for web-based educational resources. *New Rev. Hypermedia Multimedia*, 14(1), 3-32.
- Feenberg, A. & Xin, M. C. (2003). Facilitation. In A. DiStefano, K. E. Rudestarn, & R. Silverman (Eds.), *Encyclopedia of Distributed Learning*, Sage Publications, London, pp. 163-166.
- Friesen, N. (2009). Genre and CSCL: The Form and Rhetoric of the Online Posting. *International Journal of Computer Supported Collaborative Learning*, 2(4), 171-185.
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical thinking in a text-based environment: Computer conferencing in higher education. *Internet and Higher Education*, 11(2), 1-14.
- Harasim, L. (1993). Collaborating in cyberspace: Using computer conferences as a group learning environment. *Interactive Learning Environments*, 3(2), 119-130.
- Hewitt, J., Brett, C., & Peters, V. (2007). Scan Rate: A new metric for the analysis of reading behaviours in asynchronous computer conferencing environments. *American Journal of Distance Education*, 21(4), 215-231.
- Huang, Y-M., Huang, T-C., Hsieh, M-Y. (2008). Using Annotation Services in a Ubiquitous Jigsaw Cooperative Learning Environment. *Educational Technology & Society*, 11(2), 3-15.
- Lee, J. K., & Calandra, B. (2004). Can embedded annotations help high school students perform problem solving tasks using a Web-based historical document? *Journal of Research on Technology in Education*, 36(4), 65-84.
- Lee, J. M. & Jeong, A. (2009). The effects of argument mapping on critical thinking process in computer-supported collaborative argumentation. Paper presented at the American Educational Research Association Annual Conference, San Diego, April 13-17.
- Osman, G. & Duffy, T. (2009). Scaffolding critical discourse in online problem-based scenarios: The role of articulation and evaluative feedback. Paper presented at the American Educational Research Association Annual Conference, San Diego, April 13-17.
- Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education*, 16(2), 97-116.
- Rohfeld, R.W. & Hiemstra, R. (1995). Moderating discussions in the electronic classroom. In Z.L Berge & M.P. Collins (Eds.), *Computer-mediated communication and the on-line classroom in distance education*. Volume III, Chapter 5. Cresskill, NJ: Hampton Press.
- Rourke, L. & Kanuka, H. (2007). Barriers to online critical discourse. *International Journal of Computer-Supported Collaborative Learning*, 2(1), 105-126.
- Scardamalia, M. & Bereiter, C. (1994). Computer support for knowledge building communities. *Learning Sciences*, 3(3), 265-283.
- Stahl, G. (2006). *Group Cognition: Computer Support for Collaborative Knowledge Building*. Cambridge, MA: MIT Press.
- Suthers, D. D. (2007). Roles of computational scripts. In F. Fischer, I. Kollar, H. Mandl, & J. M. Haake (Eds.), *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives* (pp. 177-190). NYC: Springer.
- Wise, A.F., Duffy, T.M. & Padmanabhan, P. (2008). Deepening online conversation: How and why to use a common referent to connect learners with diverse local practices. *Educational Technology*, 48(4), 3-11.
- Xin, C. & Feenberg, A. (2006). Pedagogy in Cyberspace: The Dynamics of Online Discussion. *Journal of Distance Education* 21(2), 1-25.

Supporting Collaborative Interaction with Open Learner Models: Existing Approaches and Open Questions

Susan Bull, University of Birmingham, UK, s.bull@bham.ac.uk
Ravi Vatrupu, Copenhagen Business School, Denmark, vatrupu@cbs.dk

Abstract: In this paper we explore possibilities for open learner models to facilitate collaborative interaction and learning. We provide examples of the main approaches that use open learner models to support collaboration, and discuss some of the key issues that need to be considered for future work uniting research in the fields of computer-supported collaborative learning and open learner modelling.

Introduction

Computer-Supported Collaborative Learning (CSCL) predominantly subscribes to an intersubjective epistemology (Suthers, 2006) where the central focus is on designing artifacts for, and understanding practices of joint meaning-making (Koschmann, 2002). As such, from a human-computer interaction (HCI) perspective, usability, sociability, and learnability are three interdependent design challenges in CSCL (Vatrupu et al., 2008). Of these three design challenges, sociability has received significant attention in CSCL research (Buder & Bodemer, 2008; Kimmerle & Cress, 2008; Kreijns et al., 2002; Kreijns et al., 2007). In this paper we present Open Learner Models (OLM) as a new direction to the existing CSCL research on group awareness in particular, and sociability in general. A primary benefit of OLMs is to integrate both sociability and learnability aspects of the learning process.

The paper is organised as follows. First, we introduce and discuss OLMs. We then present the potential and promise of OLMs to foster collaborative interaction, and introduce some emerging trends. We conclude with a set of open research questions and future work directions.

Open Learner Models

OLMs have been available in adaptive educational systems for some time now. The underlying learner model (representation of learner knowledge, understanding, skills, etc.) is inferred by a system based on what has happened during an interaction with a learner or a group of learners (e.g. problem-solving tasks, specific questions, to more open-ended interaction). This allows a system to further adapt the interaction to suit individual learners, collaborating pairs or groups. OLMs have been deployed using a range of modelling techniques (e.g. constraint-based models – Mitrovic & Martin, 2007; Bayesian networks – Zapata-Rivera & Greer, 2004; fuzzy models – Mohanarajah et al., 2005; simpler weighted algorithms – Bull & Gardner, 2009).

The OLM is a human-understandable externalisation of the underlying learner model. This means that the representations used by the system to select or generate suitable tutorial interventions must (usually) be altered in some way before they are made accessible to learners. For example, as suggested by the above, the underlying system representation may be quite complex, such as in the form of programming code and/or factual statements relating to mathematical rules, scientific principles, or language rules, according to the subject being studied. More recently, interest has increased in adaptation in ill-defined domains (Mitrovic & Weerasinghe, 2009; Fournier-Viger et al., 2010), and so there may be yet more challenges for OLMs to face if such systems open a learner model for user inspection.

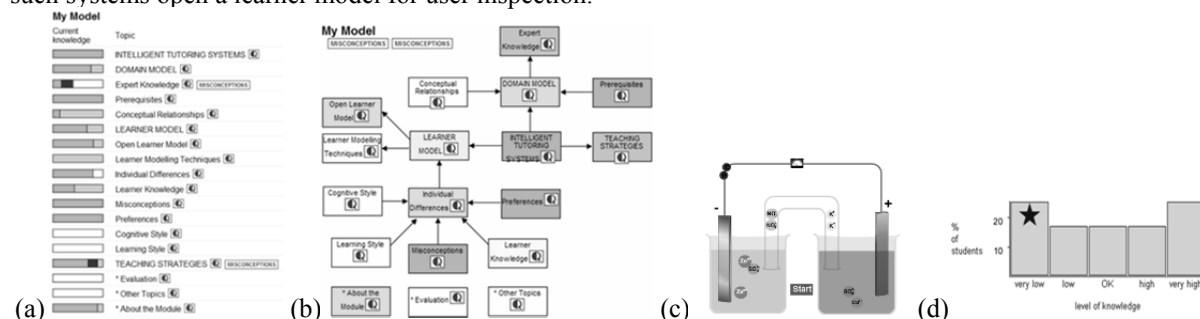


Figure 1. (a) Simple & (b) structured OLM (Ahmad et al., 2010); (c) snapshot of OLM animation (Johan & Bull, 2010); (d) simple comparison of individual to group (Bull & Britland, 2007).

Learner models can be presented to learners in a variety of ways, ranging from quite simple representations, the most common of which are a skill meter for each topic, (sub)topic or concept in the domain (e.g. Ahmad et al., 2010; Corbett & Bhatnagar, 1997; Mitrovic & Martin, 2007; Weber & Brusilovsky, 2001),

illustrated on the left of Figure 1(a); to more complex structured representations of understanding such as hierarchical trees (Kay, 1997; Mabbott & Bull, 2006); Bayesian networks (Zapata-Rivera & Greer, 2004); and concept maps (Kumar & Maries, 2007; Mabbott & Bull, 2006; Perez-Marin et al., 2007a). Figure 1(b) shows a structured map view of the learner model. Other methods of OLM presentation include simulation (Morales et al., 2000); and animations (Johan & Bull, 2010), shown for chemistry in Figure 1(c). The method of presentation of the learner model does not have to relate directly (in some way) to the underlying system representation or the modelling technique, though limitations will exist. For example, a simple underlying model of knowledge *level* as a subset or overlay of domain acquisition will not enable an OLM to display specific *beliefs* such as concepts and misconceptions.

While standards exist for learner profiling (IEEE LTSC PAPI; IMS LIP, 2001), the pedagogical characteristics included (e.g. preferences, interests, performance, competencies, amongst others), do not provide detail for how this data might be externalised to a learner in a manner consistent with many of the educational benefits aimed for by OLMs. The increased interest in opening the learner model to the user requires a means to help researchers to compare their OLMs, and learn from the developments and deployments of others. The SMILI[©] Open Learner Modelling Framework was developed for this purpose (Bull & Kay, 2007). In the following section we discuss some of the reasons for opening the model, based on this framework, but with a particular focus on the role OLMs can play in collaborative learning.

Open Learner Models to Promote Collaborative Interaction

Primary aims of OLMs include prompting metacognitive activities such as reflection, planning and self-assessment; supporting navigation; and facilitating collaboration (Bull & Kay, 2007). OLMs have achieved significant positive learning results when used by individual learners (e.g. Kerly & Bull, 2008; Mitrovic & Martin, 2007; Shahrour & Bull, 2009). We aim to foster this ability of OLMs to support learning in the collaborative context. OLMs have already been made available to allow learners to compare their progress to that of other users, or support or prompt peer interaction (e.g. Bull & McKay, 2004; Chen et al., 2007; Lazarinis & Retalis, 2007). However, work in this area is less advanced than in learner models open to the model owners (the modellees). Nevertheless, this is becoming increasingly important and relevant with widening use of social systems and students' familiarity with online social interactions, and Vassileva (2007) emphasises the integration of work in the fields of open learner modelling, interaction analysis and social visualisation.

We have identified three main current approaches to using OLMs to support collaborative interaction and learning, though systems often involve a combination of these:

- i. individual learner models that are available for peers to view;
- ii. a group model comprising data from individual team members;
- iii. a combined group model which is available to group members.

The first approach using OLMs in collaborative learning is illustrated by OLMlets, used by university students (Bull & Britland, 2007). When simple individual models (Figure 1(a)) have been released (optionally) to peers by their owners, students are able to seek out suitable collaborators for areas where they have common difficulties; or seek help from people who have stronger knowledge in areas in which they have problems (Bull & Britland, 2007). Any (or all) of these released peer models can be presented to the learner alongside his or her own model, for easy comparison. The following shows the type of interaction that has been found to occur spontaneously amongst students using OLMlets alongside their courses, as described by one of the students:

When several people were using OLMlets at the same time, most notably in one of the small computer rooms, there came to be almost a community feel. Students were comparing their model against those of people in the room, and discussions were occurring spontaneously all the time. (Bull & Britland, 2007)

This illustrates that, even when students have no specific pair or group task, they can instinctively engage in discussion with peers as a result of viewing each others' OLMs. Furthermore, this becomes a normal part of learning over time. Thus, a learning interaction that is initially used by individuals, becomes a source of information to support collaboration and peer help sessions without any (system or human tutor) intervention. Indeed, in a later experimental study it was also found that students will spontaneously discuss their learner models by viewing other users' screens, even when the option to release their models was not available (Johan & Bull, 2010). This occurred despite there being no instruction or even suggestion that they should or could do so. This further supports the possibilities for OLMs to facilitate spontaneous collaborative activities; and may also have a similar motivational role in contexts where specific pair or group interactions/tasks are defined.

Another method of supporting collaboration with OLMs is to provide a model of group interaction over time, and individuals' contributions to a joint project or task. This is illustrated by Narcissus, where the primary goal is to facilitate effective group functioning, using evidence gathered from university students' use of group work tools (Upton & Kay, 2009). Enabling group members to view the extent and type of individual

participation in a group learning context allowed team members to better identify any difficulties in the group, and work out solutions to overcome them. A major contrast to OLMlets is that all group members' participation is included in the display, reflecting that this is a group project, though a user can focus on just those peers who are relevant to them at the time. Results from Narcissus suggest that, as well as supporting learner reflection and understanding of the group interaction, the system has potential to support navigation through large and complex groupware sites (Upton & Kay, 2009). Further, examples specifically related to learner model visualisations to support team work are given in Kay et al. (2006).

A final example is a group model comprising aggregated group data (i.e. where, unlike in the previous examples, the individual peer models are not necessarily available). Such a model can allow a student to compare their own progress against the group as a whole. One method of doing this is shown (for one topic) in Figure 1(d). This also comes from OLMlets (Bull & Britland, 2007): the star shows the learner's own position against that of other group members, on a five-point scale from very low knowledge to very high knowledge. A related approach is used by Linton and Schaefer (2000), who show a user's level of knowledge against the combined knowledge of other user groups; and Tongchai and Brna (2005), who propose initially providing only a group model, before allowing users to make more direct comparisons between their own, and peer knowledge. There are many uses to which such an approach could be put, ranging from information simply for the individual, to information which a group can use together, to allow learners to *actively* consider how group members might be able to help each other and achieve their shared goal(s). This therefore also provides opportunities for the kind of metacognitive activities prompted by the first two methods.

The above suggests that there are strong roles for OLMs to help support collaborating learners, even without system or human tutor guidance. From a CSCL perspective, OLMs can empower the students to recognize and realize opportunities for learning with a more capable peer in the Zone of Proximal Development (Vygotsky, 1930/1980). The conceptual representations of OLMs can help facilitate artifact-centered discussion and engender a shared sense of a community of inquiry. Moreover, OLMs open up the possibilities for inter-group collaborative learning as an extension to the current intra-group collaborative learning emphasis of CSCL.

Open Research Questions and Future Work Directions

While there are now many examples of learner models open to individuals and increasingly also to instructors, with this trend spreading to group and peer models new issues need to be considered. For example:

Role of OLMs and OLM use

- To what extent can individual OLMs be used to support collaborative learning, and in what contexts? (E.g. voluntary sharing of models for independent spontaneous use; individual OLMs and their contribution to group knowledge, achievement, and group interaction.)
- To what extent will the expected OLMs differ according to individual roles in the group, and how might this be used to better understand group functioning?

Possible differences in OLMs for individuals

- To what extent will OLMs differ according to type of task a user is completing at the time, to a project?
- To what extent will OLMs differ according to level of input expected of (and obtained from) each participant (or subset of participants), at various points in time?
- Should all participants have the same attributes made available in a group model, or set of individual models? (Should this depend on their role within the group?)
- Should all group members receive the same learner model information at the same time? (Will this depend on their own progress or level of contribution?)

Access to OLM data

- What are the privacy issues that need consideration in peer or group models?
- How will learners feel about the availability of their learner model to other users? (Will users feel differently about data relating to their knowledge, cognitive abilities, contributions, motivation, or other social or affective states?)
- Will all group members (have to) see the same information in the same way, to facilitate collaboration? (Will this depend on their role in the group? Or on preferences for how to use learner model data?)
- What differences might there be between co-located and distributed group members?

These are only a sample of questions related to OLMs for groups. Questions are likely to differ according to the approaches most suitable in a particular collaborative learning context. For example where individuals' models are available to others, students could be allowed to choose whether to release their model data, meaning that the privacy issues relating to other users seeing their data, are in the hands of the owner of that data. This is the case in OLMlets: learners can release their model with their name, anonymously, or keep it hidden from others. Sufficient numbers of students select to release their model to encourage spontaneous collaboration amongst those who wish to work with peers (Bull & Britland, 2007). The situation becomes more complicated, however, when a user's data contributes individually to a group model, where other users can

identify who that contributor is. In a group task, the purpose of a group OLM is often to facilitate discussion, planning, production, etc. If only some users offer their model for group access, an overall (aggregated) model may be distorted; or a model containing only information about some group members (identifiably or not), may be less useful. In this case, should the group decide that all data be available? Can a group expect this, without taking away some of the rights of the model owner (i.e. control over an individual's own data)?

How will collaborations that occur spontaneously amongst users when individuals release their models to (selected or all) peers, influence group interaction if only some group members are engaging in such discussions spontaneously? Similar to the above, is it the role of a group leader (or the group collectively) to require all participants relevant to a particular issue, to be involved, thus potentially dampening any spontaneous discussion that can lead to sudden insights and advances? This may be advantageous for the group as a whole, but might an individual feel 'left out', or find it harder to catch up because others have already moved on?

An important issue related to the above question of whether a user has control over their own model data, is the situation where other users might be able to contribute information to a person's model. Peer contributions to learner models have been used in cases such as evaluating a partner after a help session in a decentralised learner model (Vassileva et al., 2003). A crucial question is the requirements if such a learner model were externalised to the learner in sufficient detail for them to recognise where the model evidence came from. What if a learner disagrees with the peer's assessment? Will this disrupt group activity?

What happens if learners are collaborating around a learner model, but prefer to access the model data in different ways? Figure 1 gives examples of different methods of presenting learner model data, and learners can have quite different individual preferences about how to view learner model information (Bull et al., 2010). To what extent will individuals be able to adapt to others' ways of viewing a learner model, when in face-to-face and distributed collaborative contexts?

How important is the timing of release of learner model information to learners? What happens if one learner becomes aware that another has access to group or individual data that they cannot see themselves? This could be possible, for example, if a threshold had to be reached before a user could access certain information; or if a team member's role does not require the information. The latter might be easier for a learner to accept, but is there a reason to restrict their access if they are interested?

Many questions have been raised here, and we do not yet attempt to answer them. But the benefits of prompting metacognitive activities for individuals using OLMs, and the positive learning gains achieved, suggest the potential of also using this approach in CSCL. A range of collaborative interaction types can be (and have been) supported by OLMs, including individual models released to peers, aggregated group models, and individual models contributing to a group model (and combinations thereof). This can help not only in structured activities, where a system may or may not have a managing role over group interaction, but also in encouraging spontaneous peer interaction. These interaction types can clearly address issues of joint meaning-making (Koschmann, 2002), as raised in the Introduction; and also encompass usability, sociability, and learnability - suggested as interdependent design challenges in CSCL (Vatrapu et al., 2008). Furthermore, they are in line with approaches to encourage work in the Zone of Proximal Development (Vygotsky 1930/1980).

Future research in CSCL should help towards resolving some of the issues, and further exploration of others; and research in open learner modelling can reciprocate, sharing findings of research into facilitating collaborative interaction around individual shared, and various kinds of group OLMs.

References

- Ahmad, N., Britland, M., Bull, S. & Mabbott, A. (2010). A Role for Open Learner Models in Formative Assessment, *Proceedings of Workshop on Technology-Enhanced Formative Assessment (TEFA)*, EC-TEL 2010.
- Buder, J., & Bodemer, D. (2008). Supporting controversial CSCL discussions with augmented group awareness tools. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 123-139.
- Bull, S. & Britland, M. (2007). Group Interaction Prompted by a Simple Assessed Open Learner Model that can be Optionally Released to Peers, in P. Brusilovsky, et al. (eds), *PING Workshop, User Modeling 2007*.
- Bull, S., Gardner, P. (2009). Highlighting Learning Across a Degree with an Independent Open Learner Model, in V. Dimitrova et al. (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam, 275-282.
- Bull, S., Gakhal, I., Grundy, D., Johnson, M., Mabbott, A. & Xu, J. (2010). Preferences in Multiple View Open Learner Models, in M. Wolpers et al. (eds), *Sustaining TEL: From Innovation to Learning and Practice, EC-TEL 2010*, Springer-Verlag, Berlin Heidelberg, 476-481.
- Bull, S., Kay, J. (2007). Student Models that Invite the Learner In: The SMILI Open Learner Modelling Framework. *International Journal of Artificial Intelligence in Education* 17(2), 89-120
- Bull, S. & McKay, M. (2004). An Open Learner Model for Children and Teachers: Inspecting Knowledge Level of Individuals and Peers, J.C. Lester et al. (eds), *Intelligent Tutoring Systems*, Springer, Berlin Heidelberg, 646-655.
- Chen, Z-H., Chou, C-Y., Deng, Y-C. & Chan, T-W. (2007). Active Open Learner Models as Animal Companions: Motivating Children to Learn through Interacting with My-Pet and Our-Pet, *International Journal of Artificial Intelligence in Education* 17(2), 145-167.
- Corbett, A.T. & Bhatnagar, A. (1997). A Student Modeling in the ACT Programming Tutor, in A. Jameson et al. (eds), *User Modeling*, Springer, New York, 243-254

- Fournier-Viger, P., Nkambou, R. & Mephu Nguifo, E. (2010). Building Intelligent Tutoring Systems for Ill-Defined Domains, in R. Nkambou et al., (eds), *Advances in Intelligent Tutoring Systems*, Springer, 81-101.
- IEEE LTSC (Learning Technology Standards Committee), *Public and Private Information (PAPI)*.
- IMS *IMS Learner Information Package Specification*, <http://www.ims-global.org/profiles>, accessed 8 Nov 2010.
- Johan, R. & Bull, S. (2010). Promoting collaboration and discussion of misconceptions using open learner models, A. Bader-Natal et al. (eds), *Proceedings of Workshop on Opportunities for Intelligent and Adaptive Behavior in Collaborative Learning Systems*, Intelligent Tutoring Systems 2010, 9-12.
- Kay, J. (1997). Learner Know Thyself: Student Models to Give Learner Control and Responsibility, *International Conference on Computers in Education*, AACE, 17-24.
- Kay, J., Maisonneuve, N., Yacef, K. & Reimann, P. (2006). The Big Five and Visualisations of Teamwork Activity, M. Ikeda et al. (eds), *Intelligent Tutoring Systems*, Springer-Verlag, Berlin Heidelberg, 197-206.
- Kerly, A., Ellis, R. & Bull, S. (2008). CALMsystem: A Conversational Agent for Learner Modelling, *Knowledge-Based Systems* 21(3), 238-246.
- Kimmerle, J., & Cress, U. (2008). Group awareness and self-presentation in computer-supported information exchange. *International Journal of Computer-Supported Collaborative Learning*, 3(1), 85-97.
- Koschmann, T. (2002). Dewey's contribution to the foundations of CSCL research. *Computer Support for Collaborative Learning (CSCL 2002)*, Boulder, CO.
- Kreijns, K., Kirschner, P., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society*, 5(1), 8-22.
- Kreijns, K., Kirschner, P., Jochems, W., & van Buuren, H. (2007). Measuring perceived sociability of computer-supported collaborative learning environments. *Computers & Education*, 49(2), 176-192.
- Kumar, A., Maries, A. (2007). The Effect of Open Student Model on Learning: A Study, in R. Luckin et al. (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam, 596-598.
- Lazarinis, F., Retalis, S. (2007). Analyze Me: Open Learner Model in an Adaptive Web Testing System, *International Journal of Artificial Intelligence in Education* 17(3), 255-271.
- Linton, F. & Schaefer, H-P. (2000). Recommender Systems for Learning: Building User and Expert Models through Long-Term Observation of Application Use, *User Modeling and User-Adapted Interaction* 10, 181-207.
- Mabbott, A. & Bull, S. (2006). Student Preferences for Editing, Persuading and Negotiating the Open Learner Model, in M. Ikeda et al. (eds), *Intelligent Tutoring Systems*, Springer-Verlag, Berlin Heidelberg, 481-490.
- Mitrovic, A., Martin, B. (2007). Evaluating the Effect of Open Student Models on Self-Assessment. *International Journal of Artificial Intelligence in Education* 17(2), 121-144 .
- Mitrovic, A. & Weerasinghe, A. (2009). Revisiting Ill-Definedness and the Consequences for ITSs, in V. Dimitrova et al. (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam, 375-382.
- Mohanarajah, S., Kemp, R.H. & Kemp, E.. (2005). Opening a Fuzzy Learner Model. *Proceedings of Workshop on Learner Modelling for Reflection*, International Conference on Artificial Intelligence in Education, 62-71.
- Morales, R., Pain, H. & Conlon, T. (2000). Understandable Learner Models for a Sensorimotor Control Task, in G. Gauthier, et al. (eds), *Intelligent Tutoring Systems*, Springer-Verlag, Berlin Heidelberg, 222-231.
- Perez-Marin, D., Alfonso, E., Rodriguez, P., Pascual-Neito, I. (2007) A Study on the Possibility of Automatically Estimating the Confidence Value of Students' Knowledge in Generated Conceptual Models, *Journal of Computers* 2(5), 17-26
- Perez-Marin, D., Alfonso, E., Rodriguez, P., Pascual-Neito, I. (2007) Automatic Generation of Students' Conceptual Models from Answers in Plain Text, in C. Conatiet al. (eds), *User Modeling*, Springer, Berlin Heidelberg, 329-333.
- Shahrour, G. & Bull, S. (2009). Interaction Preferences and Learning in an Inspectable Learner Model for Language, in V. Dimitrova et al. (eds), *Artificial Intelligence in Education*, IOS Press, Amsterdam, 659-661.
- Suthers, D. (2006). Technology affordances for intersubjective meaning-making: A research agenda for CSCL. *International Journal of Computers Supported Collaborative Learning*, 1(3), 315-337.
- Tongchai, N. & Brna, P. (2005). Enhancing Metacognitive Skills through the Use of a Group Model based on the Zone of Proximal Development, *Proceedings of LEMORE Workshop*, Artificial Intelligence in Education 2005, 91-99.
- Upton, K., Kay, J. (2009). Narcissus: Group and Individual Models to Support Small Group Work, in G-J. Houben et al. (eds), *User Modeling, Adaptation and Personalization*, Springer-Verlag, Berlin Heidelberg, 54-65.
- Vassileva, J. (2007). Open Group Learner Modeling, Interaction Analysis and Social Visualization, in V. Dimitrova, M. Tzagarakis, J. Vassileva (eds), *SociUM Workshop, User Modeling 2007*, 20-29.
- Vassileva, J., McCalla, G. & Greer, J. (2003). Multi-Agent Multi-User Modeling in I-Help, *User Modeling and User-Adapted Interaction* 13(1), 1-31.
- Vatrapu, R., Suthers, D., & Medina, R. (2008). Usability, sociability, and learnability: A CSCL design evaluation framework. *International Conference on Computers in Education (ICCE 2008)*, (CD-ROM).
- Vygotsky, L. (1930/1980). *Mind in society*, Harvard University Press.
- Weber, G. & Brusilovsky, P. (2001). ELM-ART: An Adaptive Versatile System for Web-Based Instruction, *International Journal of Artificial Intelligence in Education* 12(4), 351-384.
- Zapata-Rivera, J.D., Greer, J.E. (2004). Interacting with Inspectable Bayesian Models. *International Journal of Artificial Intelligence in Education* 14, 127-163.

Acknowledgments

This project is supported by the European Community (EC) under the Information Society Technologies (IST) priority of the FP7 for R&D under contract number 258114 NEXT-TELL. This document does not reflect the opinion of the EC, and the EC is not responsible for any use that might be made of its content.

Trustworthy in the Eye of the Beholder? - A Cognitive Perspective on Personal Profile Information in Virtual Project Teams

Ellen Rusman, Jan van Bruggen, Peter Sloep, Rob Koper, Centre for Learning Sciences and Technology (CELSTEC), Open University of the Netherlands, Valkenburgerweg 177, 6419 AT Heerlen,
 Email: ellen.rusman@ou.nl, jan.vanbruggen@ou.nl, peter.sloep@ou.nl, rob.koper@ou.nl
 Martin Valcke, Department of Educational Studies, Ghent University, Henri Dunantlaan 2, B9000 Ghent, Belgium, Martin.Valcke@UGent.be

Abstract: Collaboration in virtual project teams heavily relies on interpersonal trust, for which perceived trustworthiness is an important determinant. This study provides insight in the foundation of trustors' information preferences to assess a trustee's professional trustworthiness in the initial phase of a virtual project team. We hypothesize that trustors in virtual teams prefer particular information elements since they provide them with relevant cues for trust warranting properties of a trustee. Starting from a list of commonly preferred information elements to inform trustworthiness assessments (n=226), we analyze explanations for these preferences with the help of a theory-grounded coding scheme. Results show that indeed respondents prefer information elements as they provide them with multiple cues to assess the trustworthiness of a trustee. Information elements providing unique cues could not be identified. Results of this study can inform the design of artifacts to get acquainted in the initial phase of a virtual project team.

Introduction

A positive level of interpersonal trust improves collaboration and communication (Corbitt, Gardiner & Wright, 2004; Gambetta, 1988; Jarvenpaa, Knoll, & Leidner, 1998; Jarvenpaa & Leidner, 1998). In contrast, when there is a lack of trust, team members spend considerable time monitoring each other, backing-up or duplicating work, and documenting problems (Wilson, Straus, & McEvily, 2006). Interpersonal trust is a positive psychological state (cognitive and emotional) of a trustor (person who can trust/distrust) towards a trustee (person who can be trusted/distrusted). It comprises trustor's positive expectations of the intentions and future behaviour of the trustee, leading to a trustors' willingness to display trusting behaviour in a specific context (Castelfranchi & Falcone, 2010; Chopra & Wallace, 2002; Hung, Dennis & Robert, 2004; Mayer, Davis & Schoorman, 1995; Riegelsberger, Sasse & McCarthy, 2004; Rousseau, Sitkin, Burt, & Camerer, 1998; Ulivieri, 2005). Although interpersonal trust is both an important pre-condition of, as well as a result of collaboration, still little is known about how we can foster its formation.

One promising approach is to facilitate trustworthiness assessments. The perceived trustworthiness is an important factor influencing overall interpersonal trust of a trustor in a trustee, in combination with a trustors' trust propensity, situational characteristics (e.g. perceived risk, task complexity, social control mechanisms) and trustors' mood at the time of trust formation (Castelfranchi & Falcone, 2010; Riegelsberger, 2005; Rousseau et al., 1998). The extent to which the trustor trusts the trustee to perform adequately is the trustee's perceived trustworthiness (Hardin, 2002). A trustor, when not knowing a trustee, continuously tries to gauge the trustworthiness of a trustee based on available signs and signals revealing the properties of a trustee. Once these signals are used to reveal a certain perceived property of another, they become cues for that property (Donath, 2007). Signs and signals can be related to trustees characteristics, such as their facial expression or education, as well as to behavior, such as providing help or being open about task problems (Six, Nooteboom & Hoogendoorn, 2010). In mediated environments, these signs and signals are different or hampered.

The availability of signs and signals can be stimulated by providing communication support through pre-structured templates (Aranda et al., 2010; Remidez, Stam & Laffey, 2007; Ten Kate, 2009). These templates should then be designed to contain that personal information that is useful to assess the trustworthiness of a trustee, through the display of particular information elements. Information elements are small containers for data about a person. Examples are 'name', 'photo', 'hobbies', 'job title' and so on.

If one knows what type of information trustors prefer to inform their trustworthiness assessments and why they have this particular preferences, one could provide a pre-structured template to facilitate the availability of this information (Rusman, van Bruggen, Cörvers, Sloep & Koper, 2009). However, until today it remains unclear what specific personal information most trustors prefer and why. We do know that personal information can facilitate the growth of interpersonal trust (Zolin, Fruchter & Hinds, 2003; Feng, Lazar & Preece, 2004), but we do not know what specific information supports trustworthiness assessments.

We hypothesize that trustors seek specific information that matches with their cognitive schema of trustworthiness while they try to instantiate this schema to assess the trustworthiness of a specific trustee. This schema guides their search for information that can function as cues for trust-warranting properties of a trustee.

We test whether trustors prefer information elements that provide these cues to determine whether someone is trustworthy. We try to answer the following question:

Do trustors prefer those information elements that provide them with (relevant/multiple/unique) cues for specific trust-warranting properties?

The answer to this question provides insight in the foundation of information preferences, which can guide the design of communicative templates as well as icebreaker activities in both face-to-face as well as virtual teams.

Method

A questionnaire was used to collect data on common information element preferences to inform trustworthiness assessments as well as justifications of these preferences. Based on a ranked list with the fifteen most commonly selected information elements, we analyzed the explanations respondents gave for their preferences with the help of a coding scheme.

Participants

Data were collected among bachelor level students, enrolled in a research course in the Educational Sciences program at the Ghent University. 226 students (mean age = 18,2 years, SD= 1,85; 93% of whom were female and 7% male.) filled out the questionnaire: 99% of the respondents had previous experience with collaboration in a face-to-face project team, either in a (part-time) job or during their study. 95% had previous experience with collaboration in a virtual project team. 88% of the respondents had experience with online conversations with people they had never met before. The majority of online conversations took place via text-based media only, either via chat and/or e-mail (78%) or in combination with SMS (9%).

Instrument

The questionnaire consisted of two parts and contained open as well as closed questions in the respondents' native tongue (Dutch). The first part questioned respondents on their information element preferences to inform trustworthiness assessments. It contained an open brainstorm followed by the rating of elements (useful to inform their assessment/practical for collaboration) from a pre-defined list. The second part aimed to provide insight in the foundation of these preferences. In this paper we restrict ourselves to the analysis of the second part. Here, participants selected the 10 most important information elements to inform their trustworthiness assessments from all elements obtained in the first part of the questionnaire. They were instructed to justify their choices by explaining what 'facts' they thought they could derive from an information element and why this was important to inform their trustworthiness assessments.

Procedure

The participants filled out the questionnaire after a short presentation that clarified our definition of virtual project teams and that showed some examples. The presentation also discussed the role of interpersonal trust for collaboration and the objectives of the questionnaire. At the start of the questionnaire, respondents were prompted by a scenario in which they acted as a member of a new European project, which required them to collaborate in a virtual project team. They were told that they had to form a first impression of their team members' trustworthiness. Respondents were told that the responses to this questionnaire would be kept anonymous and that it would take about 30 minutes to complete this part of the questionnaire. Table 1 provides an example (translated) of the collected responses.

Table 1: Example response.

Preferred information element	Facts which can be derived from this information element	Explanation of preference
Personal motivation for project	Reason for participation; expectation(s) of project	You get to know whether you are on the same wavelength. Do you have the same expectations?

Data Analysis

We first identified the 15 information elements that were most commonly mentioned as highly informative for trustworthiness assessments. Secondly, all explanations linked with this top 15 were gathered and coded with the help of a coding scheme. The coding scheme was derived from a theoretical framework for interpersonal trust building in virtual teams, called TrustWorthiness ANtecedent schema (TWAN) (Rusman et al., 2010). Some categories were added to allow for explanations which were not related to trust building at all, or that were examples of antecedents of interpersonal trust or trustworthiness not yet mentioned in any of the

predefined categories. We coded 1) whether trustors' explanations of their information preferences match with the trustwarranting properties of a trustee; 2) whether and how they adhere to the trust formation process in general or 3) whether they are not related to interpersonal trust at all. We report the results of the first part of the coding scheme.

Each explanation was considered as a coding unit, multiple different codes were allowed, but no similar double codes were allowed. Two raters individually coded 10% of the explanations with the help of the coding scheme (Neuendorf, 2002). The interrater-reliability (Cohen's Kappa) was 0.79 for the coding with the TWAN schema only and 0.73 for the coding with the complete coding-scheme. According to Fleiss (1981), this can be considered a good (0.6-0.75) to excellent (> 0.75) interrater-reliability. The remaining responses were analyzed by one rater only.

Not all respondents provided explanations of their information preferences. We counted the possible-to-code explanations per information element and expressed the frequencies of 'code-use' in percentages relative to this number of explanations.

Results

Competence (40%), Commitment (26%), Responsibility (17%), Availability (12%) and Communitality (7%) were the most frequently mentioned antecedents of professional trustworthiness across all explanations given with the 15 most selected information elements (percentages are expressed relative to the total number of used codes). Table 2 gives some example quotes of the top 3 antecedents mentioned with regard to different information elements. The first and second example also illustrate how a single explanation can be coded with more coding categories, since they contain elements of competence as well as of the route through which information was obtained.

Table 2: Example quotes.

Antecedent	Example quotes with adjoining information element
Competence	<p>"I will perceive someone with more work experience as more reliable as this person will probably do his job well when he could work for several years within a company and he will also, through experience, know more" (<i>work experience</i>)</p> <p>"An older person has more work experience and if he/she is selected to participate in the project he/she has proven to be reliable" (<i>age/date of birth</i>)</p> <p>"How well one can manage languages, positive or negative. It is important to master some languages to advance communication, especially in an international project" (<i>language proficiency</i>)</p>
Commitment	<p>"Number of professions someone had. Rising functions relative to their age. If someone works one's way up, they will also spend more time and energy in the project, therefore you can count on this person" (<i>work experience</i>)</p> <p>"Why someone participates in a project. If someone participates involuntary, he/she will probably less motivated than someone who participates voluntarily" (<i>personal motivation</i>)</p>
Responsibility	<p>"You will know whether someone will dedicate him/herself [to the project] and of what one is capable of. Someone who makes sincere choices is more reliable in accomplishing the task. Someone with ambition already proved that he/she is suitable." (<i>personal motivation</i>)</p> <p>"Someone older has usually more life and work experience. Therefore he/she can also take more responsibility and is autonomous" (<i>age</i>)</p>

Respondents also mentioned various other antecedents (11%), which were not part of the trustworthiness antecedent schema, such as stubborn, enterprising, creative, flexible, respectful, independent/autonomous, enthusiastic and cheerful. Table 3 provides an overview of the code frequencies expressed in terms of percentages calculated relative to the number of obtained explanations for each information element. Different codes per explanations where possible, which explains why sums of percentages exceed 100. The percentage indicates how often respondents mentioned one of the antecedents in the explanations for their information element preferences. As we are interested in the relation between the preference of information elements and the rationale behind this preference, antecedents mentioned in more than 10% of the provided explanations are highlighted.

Table 3: Code frequencies expressed as percentages of the number of obtained explanations.

Codes	Availability	Caring	Communality	Commitment	Competence	Consistency	Discretion	Fairness	Faith in intentions	Friendliness	Willingness to help	Honesty	Integrity	Knowledge	Loyalty	Openness	Other antecedent	Persistence	Receptivity	Reliability	Responsibility	Sharing	Skills	
1. Personality traits/ character	4	11	8	27	15	10	0	0	2	7	1	6	5	0	0	13	69	10	10	4	5	0	1	
2. Work experience	1	2	0	14	91	11	0	0	0	0	8	2	1	9	0	0	10	4	1	2	27	0	9	
3. Personal motivation for project	12	1	6	92	8	1	0	0	2	0	0	0	7	0	0	0	4	13	0	5	34	0	0	
4. Education/ studies/ training/ diplomas	1	0	1	27	88	0	0	0	0	0	0	0	1	23	0	0	0	6	0	0	35	0	4	
5. Age/date of birth	0	0	22	3	73	5	0	0	0	0	0	1	0	5	0	1	3	0	0	6	2	0	0	
6. Availability during project/ agenda	89	0	1	30	4	4	0	0	0	0	0	1	0	1	0	0	0	1	0	7	22	0	0	
7. Recommendations/ references/ reviews by third parties	0	0	0	15	32	0	0	0	0	0	0	6	0	0	0	0	0	0	0	3	27	0	0	
8. Project work experience	0	0	0	14	51	0	0	0	0	0	5	0	0	0	0	0	0	2	0	2	7	0	7	
9. Language/ language proficiency/ language skills	2	0	8	11	81	0	0	0	0	0	3	0	0	5	0	0	5	0	0	0	8	0	45	
10. Photo (formal/ informal)	0	0	2	2	2	0	0	0	0	2	0	0	0	0	0	5	5	0	0	0	0	0	0	0
11. Interests/ hobbies	13	9	21	34	11	0	0	0	0	0	0	0	0	2	0	2	7	0	0	0	21	2	0	
12. Family situation/ marital status	36	2	4	10	12	0	0	0	0	0	0	0	6	0	0	4	8	0	0	0	10	0	0	
13. Ideas in relation to project	0	0	21	54	33	0	0	0	0	0	3	0	0	3	0	3	15	0	3	0	10	3	8	
14. Occupation/ function/role/ job	7	0	2	17	76	2	0	0	0	0	0	0	0	13	0	2	13	7	0	0	20	0	9	
15. Nationality	19	2	28	0	2	0	0	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	

Several antecedents were not at all mentioned as a rationale in the explanations of the 15 most commonly preferred information elements, respectively discreteness, fairness and loyalty. For most information elements, respondents used explanations which could be analyzed in terms of the trustworthiness antecedent schema. Only for the information element ‘photo’ no clear relationship with any trustworthiness antecedent was obtained.

Conclusion and Discussion

Results indicate that trustors value information elements that may reveal information that corresponds to multiple properties of a trustworthy person (as represented in the TWAN schema) most. Especially the antecedents of competence, commitment, responsibility, availability and communality were most often referred to in their explanations. However, respondents did not refer to all antecedents in the TWAN schema: Discreteness, fairness and loyalty were not mentioned at all in the explanations provided with the top 15 most preferred information elements. This could be a result of the focus on the *initial phase* of trust formation, in which some antecedents can be assessed more easily than others. It might also indicate that some antecedents are more heavily emphasized than others when assessing professional trustworthiness.

Participants seem to select information elements that provide multiple cues for multiple antecedents. We could not find proof for the hypothesis of the uniqueness of information elements as cues; most information elements functioned as cue to more than one trustworthiness antecedent. This could be an indication of an ‘information efficiency’ strategy of trustors; preferring elements that provide cues for more than one trustworthiness antecedents. Reversely, some patterns between information elements and antecedents could also be identified. There seem to be stronger relations between for example the information elements ‘work experience’, ‘education’, ‘age’, ‘language skills’ and the antecedent ‘competence’. Likewise relations can be seen between the elements ‘personal motivation’, ‘ideas in relation with a project’ and the antecedent ‘commitment’. Results also reveal that not all information preferences can be explained with the cognitive schema of trustworthiness: some information elements, such as a photo, seem to be selected because they provide trustors with a certain ‘feeling’ about a trustee.

Results of this study are twofold. First, insight in the foundation of information preferences can guide the design of artifacts to get acquainted and to inform trustworthiness assessments in virtual teams, such as profiles. These designs might also prove useful within the context of CSSL. Second, the coding scheme could also function as an analysis framework for interpersonal trust related problems in collaborative settings. Further research is needed to verify whether the scheme can indeed fulfill this function.

References

- Aranda, A., Vizcaíno, A., Palácio, R. & Morán, A. (2010). *What information would you like to know about your co-worker? A case study*. Paper presented at the 5th International Conference on Global Software Development (*ICGSE'10*), 23-26 August 2010. New Jersey. USA.
- Castelfranchi, C., & Falcone, R. (2010). Chapter 2. Socio-Cognitive Model of Trust: Basic Ingredients. In C. Castelfranchi & R. Falcone, *Trust Theory. A Socio-Cognitive and Computational Model* (pp.35-94). Chichester: Wiley & Sons.
- Chopra, K., & Wallace, W. A. (2002). *Trust in electronic environments*. Paper presented at the HICSS 03, Hawaii.
- Corbitt, G., Gardiner, L., & Wright, L. (2004). *A comparison of team developmental stages, trust and performance for virtual versus face-to-face teams*. Paper presented at the 37th Hawaii International Conference on System Sciences, Hawaii.
- Donath, J. (2007). Signals in social supernets. *JCMC*, 13(1), article 12
- Feng, J., Lazar, J., Preece, J. (2004). Empathy and online interpersonal trust: a fragile relationship. *Behaviour and Information Technology* 23 (2), 97–106.
- Flleiss, J. L. (1981) *Statistical methods for rates and proportions*. New York: John Wiley.
- Gambetta, D. (1988). *Trust: making and breaking cooperative relations*. Oxford: Basil Blackwell.
- Häkkinen, P. (2004). What makes learning and understanding in virtual teams so difficult? *Cyber Psychology & Behavior*, 7(2), 201-206.
- Hardin, R. (2002). *Trust and trustworthiness*. New York: Russell Sage Foundation.
- Hung, Y. C., Dennis, A.R., & Robert, L. (2004). *Trust in Virtual Teams: Towards an Integrative Model of Trust Formation*. Paper presented at the 37th Hawaii International Conference on System Sciences, Hawaii.
- Jarvenpaa, S., & Leidner, D. (1998) Communication and trust in global virtual teams. *JCMC*, 3(4)
- Jarvenpaa, S., Knoll, K., & Leidner, D. (1998). Is Anybody Out There?: The Development of Trust in Virtual Teams. *Journal of Management Information Systems*, 14(4), 29-64.
- Mayer, R. C., Davis, J. H., & Schoorman, D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.
- Neuendorf, K. A. (2002). *The Content Analysis Guidebook*. Thousand Oaks: Sage Publications, Inc.
- Riegelsberger, J., Sasse, M. A., & McCarthy, J. (2004). The mechanics of trust: a framework for research and design. *International Journal of Human-Computer Studies*, 62(3), 381-422.
- Remidez, H., Stam, A., & Laffey, J. (2007). Web-Based Template-Driven Communication Support Systems: Using Shadow netWorkspace to Support Trust Development in Virtual Teams. *IJeC*, 3(2), 65-83.
- Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). "Not so different after all: a cross-discipline view of trust". *Academy of Management Review*, 23(3), 393-404.
- Rusman, E., Bruggen, v., J., Cörvers, R., Sloep, P., & Koper, R. (2009). From pattern to practice: Evaluation of a design pattern fostering trust in virtual teams. *Computers in Human Behaviour*, 25(5), 1010-1019.
- Rusman, E., Van Bruggen, J., Sloep, P., & Koper, R. (2010). Fostering trust in virtual project teams: Towards a design framework grounded in a TrustWorthiness Antecedents (TWAN) schema. *International Journal of Human Computer Studies*, 68(11), 834-850.
- Six, F., Nootboom, B., & Hoogendoorn, A. (2010). Actions that Build Interpersonal Trust: A Relational Signalling Perspective. *Review of Social Economy*, 68(3), 285-315.
- Ten Kate, S. (2009). *Trustworthiness within Social Networking Sites: A study on the intersection of HCI and Sociology* (Unpublished Business studies master's thesis). University of Amsterdam, Amsterdam.
- Ulivieri, F. (2005). *Trust across disciplines*. T3Group - Trust: Theory and Technology. Rome: Institute of Cognitive Sciences and Technology.
- Wilson, J. M., Straus, S. G., & McEvily, B. (2006). All in due time: The development of trust in computer-mediated and face-to-face teams. *Organizational Behavior & Human Decision Processes*, 99(1), 16-33.
- Zolin, R., Fruchter, R., & Hinds, P. (2003). *Communication, Trust & Performance: The Influence of Trust on Performance in A/E/C Crossfunctional, Geographically Distributed Work*. Stanford: Center for Integrated Facility Engineering (CIFE), Stanford University.

Acknowledgments

We would like to thank the Ghent University students for their dedicated collaboration.

Detecting Collaboration Regions in a Chat Session

Dan Banica, Stefan Trausan-Matu, Traian Rebedea, University “Politehnica” of Bucharest, Department of Computer Science and Engineering, 313 Splaiul Independentei, Bucharest, Romania
 Email: dan.banica@cti.pub.ro, stefan.trausan@cs.pub.ro, traian.rebedea@cs.pub.ro

Abstract: The paper presents an approach and a software system for the automatic detection of collaboration regions in a chat session. Although there is no unanimous accepted definition of good collaboration regions, they are generally easy to recognize, as their most important properties are known: they contain replies from more participants, the replies are on-topic and the participants elaborate together, they construct starting from the ideas begun by others. This is in opposition to the case of participants discussing in parallel, ignoring each other. Perfectly detecting collaboration regions involves understanding the natural language, which is an AI-complete problem, not solvable for the moment. However, we will show in this paper that good approximations can be done by using some heuristics. We will present a few such techniques, as well as a framework for detecting collaboration regions starting from a Bakhtinian perspective.

Introduction

Computer Supported Collaborative Learning (CSCL) aims to facilitate interactions between students, or between tutors and students using computers. Numerous tools allow users located far away to communicate, one of the most representatives being the chat systems (Stahl, 2006). In this paper we present an approach for analyzing a chat discussion and identifying regions with a good collaboration. Such regions occur when more participants are involved, discuss on-topic and elaborate together, as opposed to the case when they ignore each other, each exposing only his own ideas.

There are few systems that analyze chat conversations. For example, TagHelper (Rose & all, 2008) uses Natural Language Processing and Machine Learning techniques for tagging utterances, starting from annotated corpora. Dong’s approach (Dong, 2006) is in some aspects similar to ours because it analyzes globally the chat for detecting concept formation, but he applies other analysis techniques and it don’t detect collaboration regions.

The corpus used for analysis was developed at the University “Politehnica” of Bucharest which consists of chats held in the VMT (Stahl, 2009) environment which has an important advantage – it allows participants to specify to what reply they are answering, using *explicit links*. This is done by clicking another utterance before submitting a reply. The scenario assigned for the chats is the following: each participant must choose a collaborative technology (chat, blog, wiki and forum) and in the first part of the talk he must try to convince the others that his technology is the best. In the second part, the learners must try to reach a consensus discussing how they could integrate the technologies in order to get the best usage scenario in a company.

This paper is structured as follows: in section 2 we will introduce a theoretical framework and the algorithms used by the system. Section 3 describes the heuristics that can be applied in order to estimate the collaboration in a chat, while section 4 presents several results. We end the paper with conclusions and future work.

Theoretical Framework

As a starting point, we used one of Michael Bakhtin’s ideas: “Utterances are not indifferent to one another, and are not self-sufficient; they are aware of and mutually reflect one another. These mutual reflections determine their character. Each utterance is filled with echoes and reverberations of other utterances to which it is related by the communality of the sphere of speech communication. Every utterance must be regarded primarily as a response to preceding utterances of the given sphere (we understand the word <<response>> here in the broadest sense). Each utterance refutes, affirms, supplements, and relies on the others, pre-supposes them to be known, and somehow takes them into account” (Bakhtin, 1986).

It is obvious that implementing a computer program starting from this theory will require some simplifications of Bakhtin’s ideas. Nevertheless it offers us all the time a perspective from which to investigate a conversation. According to Bakhtin, each utterance adds some aspects to the discussed topics and in the same time it takes into account the aspects revealed by previous utterances. The extent to which an utterance is based on another varies: it can be an explicit answer, or it can contain only an “echo” of the previous one. Simply because the author is aware of the previous utterance indicates an existing link. From this point of view, between any two utterances there is some degree of collaboration, lower or higher. In our system we modeled this as a complete, weighted graph, utterances being the nodes and the weight of an edge being the degree of collaboration between them. We will call this the *collaboration graph*.

This degree of collaboration (weights of the edges) is estimated using some heuristics. A *zone (region) of the chat* is considered a set of at least two nodes corresponding to consecutive utterances in the chat. The terms *zone* and *region* shall be used interchangeably. We define the *total collaboration of a zone* as the sum of the individual collaborations formed between utterances inside that zone. Figure 1 below illustrates this notion. The total collaboration of region S is the sum of weights associated to edges that are completely contained in the rectangle. Although the graph of collaboration is a complete graph, for simplicity, in the figure we did not draw all the edges. Note that the total collaboration is not a measure of how good a collaboration region is. A long region will finally accumulate a large total collaboration, without necessary being a good collaboration zone in the sense we want. To solve this difficulty we defined the notion of *attenuated collaboration of a zone* or simply *collaboration of a zone*, which is the total collaboration divided by some function which increases with the zone's length. We now define a *zone with a good collaboration* as a zone having the attenuated collaboration above a threshold.

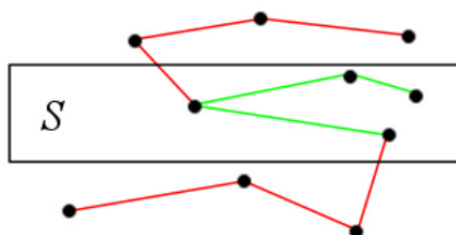


Figure 1. Total Collaboration of a Region.

So far we have defined some notions with the purpose of quantifying a region with a good collaboration. We can at this moment design an algorithm for detecting these zones. First, we will assume that the weights in the collaboration graph are already known, reducing the problem to one involving graphs only. In section 3 we will see methods for actually computing these weights (i.e. estimating collaboration between pairs of utterances).

We analyze the possibility of computing the collaboration for all zones in a chat. This involves computing $\frac{n(n-1)}{2}$ values, where n is the number of utterances, because any two utterances bi-univocally determine a region: the region that is starting from the first utterances in the pair and ends at the second one. Recall that a zone must contain at least two utterances. All these values can be efficiently computed using an algorithm that has a low computational complexity. The key in devising this algorithm is to first compute the total collaboration for each region, pre-computing the values $S(p, q) = \sum_{i=p}^q w_{i,q}$. Note that $S(p, q)$ is actually the contribution in terms of total collaboration that utterance q brings to the region starting from utterance p ending at utterance $q-1$, when this region is being extended to also include utterance q .

Now, that we have the collaboration associated with each zone of the chat, one more aspect remains to be solved. We must select a set of zones in order to present them as high collaboration regions. Simply presenting the zones with collaboration higher than some threshold elicits the problem that overlapping regions will appear. Indeed, starting from a high collaboration zone and removing the last utterance will probably lead to another zone with high collaboration. However, we do not want both these regions to appear in a selection of high collaboration zones. We have used a greedy-type solution, i.e. at each step we choose the best collaboration region that have not been yet chosen or rejected and then reject all other regions that overlap this one. We say that two regions overlap if they have at least one common utterance. In order to implement these ideas, we first sort the regions according to collaboration values, and then we go through them starting from the one with the highest value, for each region checking whether it intersects any of the previous selected ones. Typical values of k , the number of selected regions are in the range 10-20. In our corpus chats generally had below 400 utterances. For such values analyzing a chat is almost instant on any computer.

The usage of this greedy approach for selecting regions is not only computationally favorable. We claim that it also makes a good selection of regions. To gain some insight into this, consider the case illustrated in Figure 2. Suppose region S has a higher collaboration than each of the regions T_1, T_2, \dots, T_n which are also good collaboration regions (with collaboration above a threshold) that intersect S . Choosing S instead of T_1, T_2, \dots, T_n seems a good alternative, because while S is the zone with the highest collaboration, all the T_i regions are probably good collaboration zones just because they share utterances with S .



Figure 2. Example of Using the Greedy Algorithm to Select Collaboration Regions.

Heuristics for Estimating Collaboration

This section discusses the second part necessary for implementing the automatic detection of collaboration regions. We assumed so far that we know the collaboration score between individual utterances (the weight of the edges in the collaboration graph), and designed the selection algorithms without worrying about these values. In this section, we will present some features used for estimating these collaborations between utterances.

The first feature taken into account is represented by the *explicit links*. During a discussion in the VMT environment, participants can specify before sending a reply that it is a response to a previous one. Therefore, the fact that an utterance U_2 has an explicit link to another one, U_1 , suggests a powerful collaboration between these two replies. Furthermore, if U_1 contains an explicit link to another utterance U_0 , then this link, besides the collaboration between U_1 and U_0 , also indicates some collaboration (however, a lower one) between U_2 and U_0 . This is in concordance with Bakhtin's idea exposed in the previous section. In our implementation, starting from an utterance U , we go back on the chain of explicit links and associate smaller and smaller collaborations between U and utterances found.

Explicit links have some problems that must be treated by other heuristics. Most important, the majority of chat systems don't offer this facility, and even when they do, it is not always used by the participants. If at a given moment of the conversation multiple parallel threads exist, these threads will never be joined by explicit links. It would be useful to determine whether these threads are really independent, or whether they just discuss alternative aspects of the same subject. In the second case, threads are somehow related and overall, the zone should have a better collaboration than it would if the threads were discussing different topics.

When explicit links are missing or just in order to adjust the values offered by them we can use another criterion which should detect links between utterances: *common concepts*. If the same word appears in two different, but nearby replies, then probably there is some link between the two utterances. We don't restrict the search to exactly the same word: if two words have the same stem or are synonyms, they are also considered the same concept, increasing thereby the connection between the utterances.

There can be some zones into a discussion where participants collaborate but outside of the desired topics. These zones are not of interest to us as they are off-topic. In order to increase the bonus for on-topic collaboration, we introduced a criterion which uses a list of keywords. If an utterance contains some of these words then it probably is on topic, therefore the collaborations in which this utterance is involved are increased.

Another feature used to evaluate the degree of collaboration is represented by speech acts and argument models. A speech act represents a function that an utterance possesses in a conversation - some examples of speech acts are greeting, request, complaint, invitation, etc. Generally, utterances that belong to a certain speech act might be formed by a single word or might be arbitrary long. However, for many speech acts some patterns can be identified in which the corresponding utterances fit. By using a pattern matching mechanism, a module of the PolyCAFe system developed under the LTfLL project (www.ltfll-project.org) detects the speech act of each utterance. Elements that belong to the process of argumentation are identified in the same way. These elements correspond (with small variations) to the model introduced by Stephen Toulmin and are the following: claim, ground, qualifier, rebuttal and concession (Toulmin, 1958). Knowing to what category an utterance belongs is useful for our program. For example, an utterance that is a concession probably is involved in a high collaboration with another reply. On the other side, a greeting is not interesting from our collaboration perspective, so although a participant might use an explicit link when greeting another, the collaboration involved should not be taken into account (we only consider on-topic collaboration).

Results and Heuristics Evaluation

A first important result is obtained by using only explicit links for evaluating the collaboration. A zone obtained using this method is shown in Figure 3. Looking at the graph on the right of the figure (the nodes represent utterances and edges represent explicit links), it can be seen that we have a good edge-density. Although we have shown earlier a series of problems that explicit links have, we mention that if the participants make intensive use of the facility, using this criterion alone for estimating good collaboration regions we obtained very promising results. As stated before, an important problem is that participants don't always use this option.

We have chosen one of the chats from our corpus that contains many explicit links (in this discussion over 75% of the utterances use this facility). We computed the collaboration of every possible region twice:

once using only the explicit-links heuristics, once using other heuristics. Between these two sets of values the Pearson correlation coefficient was computed. If this coefficient is close to 1, then the results obtained by using the second criterion are in concordance with those obtained using only the explicit links. Several alternatives were explored in order to analyze the heuristics, as shown below.

Variant 1: We have used only a restricted version of the criterion “common concepts” defined above, giving a bonus if two replies have a common word – not taking into account neither the distance between the utterances, nor inflationary forms of the same word. We obtained a correlation coefficient of 0.032. This value doesn’t indicate the existence of any similarity relative to the values obtained by using only the explicit links.

Variant 2 improves the criterion of common concepts by taking into account the distance between utterances. The intuition is that although two utterances share a common word, if they are far from each other, they are probably not very much related. In order to implement this in our program, the constant bonus accorded for each common word is divided by the distance between the two utterances. This way we have a significant increase in the correlation, which boosted it up to 0.67.

Variant 3: we continue the improvement starting from variant 2, now also using the frequency of the repeated word. In consequence, when a common word is found, the bonus will depend not only on the distance between the two words, but also on the frequency of the word: the more frequent it is in our chat, the less we increase the corresponding value of the collaboration. Thus, we obtained another important increase in the Pearson correlation that was 0.79.

Variant 4: continuing from variant 3, but allowing the words to have the same stem we obtained a small improvement, correlation = 0.80. For this example, the benefits obtained from using stemming are not significant. Further tests should be undertaken in order to more precisely see how useful this feature is.

Variant 5: starting from variant 4 and taking into account some speech acts and argumentation elements, (e.g.: increasing the collaborations that involve a “concession”), we obtained this way a correlation of 0.82. Again, this is a small increase, and the precise effect must be further analyzed. However, overall we obtained promising results, indicating that what can be obtained by using the explicit link structure - which possesses semantic information - can also be obtained using these kind of heuristics.

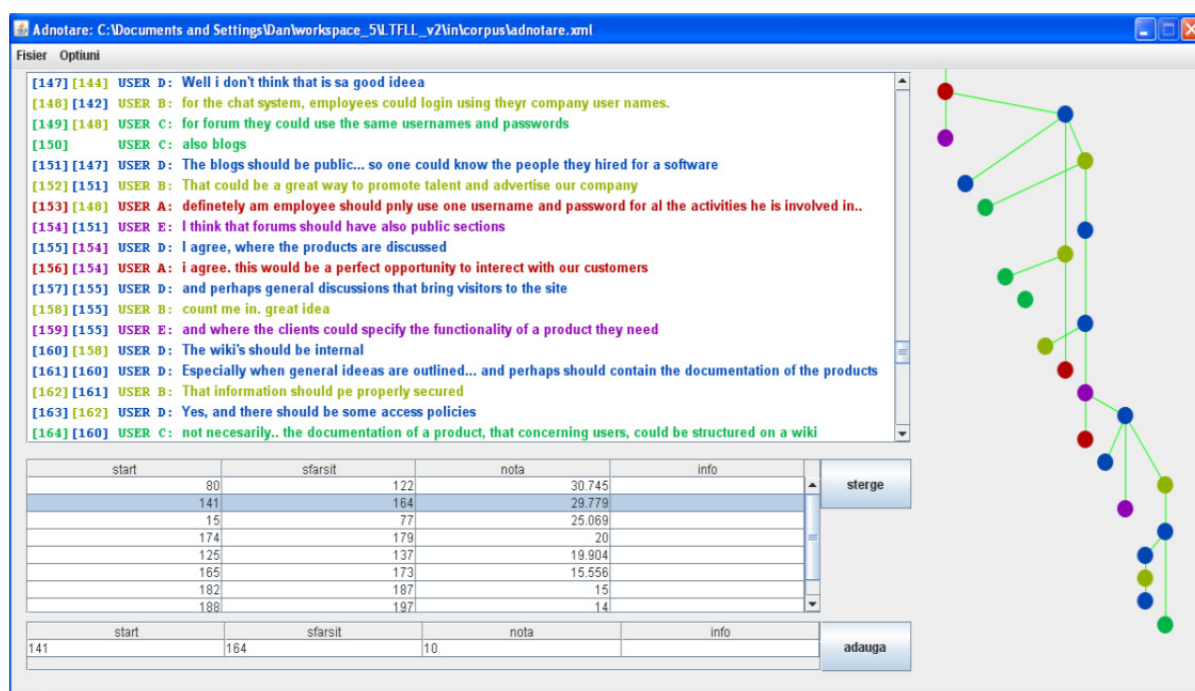


Figure 3. A Good Collaboration Zone Obtained Using Only Explicit Links.

Figure 3 presents a screenshot of the system we developed in order to provide a better visualization of the zones with a high collaboration in a chat. In the upper-left is the chat log. The first number (in square brackets) is the identifier of the utterance, while the second number is the identifier of the explicitly referred utterance. Each participant has a distinct color and their names are automatically anonymized (this option may be disabled in order to show participants’ real names).

Below the conversation, we listed the zones detected as having a good collaboration. The first two columns represent the identifiers of the first and the last utterances in the region, while the third column shows the score of the collaboration region as computed by our system. However, the tutor has the possibility to

manually edit each of these values, and also to add or remove lines in this table. For convenience we added a fourth column where he can add comments and observations regarding each collaboration zone.

By clicking on a cell of the table, the corresponding region is selected and is represented in the graph displayed on the right part of the image. The nodes correspond to the utterances in the selected region and the edges represent explicit links inserted by participants during the chat. A node has the color of its author, and by moving the mouse above it, the text is shown as a tooltip text.

A verification of the developed system was done by comparing its results with those provided by the PolyCAFe system (Trausan-Matu and Rebedea, 2010, Dascalu, Rebedea and Trausan, 2010) and those manually identified by other persons than the developer. The results of the system were very similar with those of the human and better than those of PolyCAFe.

Conclusions and Future Work

We implemented a system for automatically identifying the zones of a chat with a good collaboration. First we created a theoretical framework, being guided by an idea stated by the Russian philosopher Mikhail Bakhtin. We considered that between any two utterances there is some degree of collaboration. Starting from this point we derived a few notions leading us to defining what a good collaboration region is and implemented the algorithms that allow us to efficiently extract these regions. Besides this theoretic framework, we also devised a couple of heuristics that estimate the collaboration between a pair of utterances. In this paper we described and analyzed these heuristics. We have shown that the explicit links which are possessing semantic information can be approximated using some heuristics that are based on a rather lexical analysis. These initial results are promising and future research includes testing new heuristics, for example some based on Social Network Analysis (perhaps collaboration appears more between persons with a similar rank). Another improvement would be to take into account more powerful semantic similarity measures that would extend the lexical and WordNet based ones defined in the paper: to this extent, Latent Semantic Analysis, like in Dong's (2006) system and more powerful semantic distances or lexical chains could be used.

References

- Bakhtin, M. (1986). *Speech Genres and Other Late Essays*. University of Texas, Austin.
- Dascalu, M., Rebedea, T. & Trausan-Matu, S. (2010). A Deep Insight in Chat Analysis: Collaboration, Evolution and Evaluation, Summarization and Search, *AIMSA 2010*, LNAI 6304, Springer, 191-200.
- Dong, A. (2006) Concept formation as knowledge accumulation: A computational linguistics study, *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 20, 1, 35-53
- Rose, C. P., Wang, Y.C., Cui, Y., Arguello, J., Stegmann, K., Weinberger, A., Fischer, F. (2008). Analyzing Collaborative Learning Processes Automatically: Exploiting the Advances of Computational Linguistics in Computer-Supported Collaborative Learning, *International Journal of Computer Supported Collaborative Learning*, Vol.3, nr.3, 237-271
- Stahl, G.: (2006). *Group Cognition: Computer Support for Building Collaborative Knowledge*, MIT Press.
- Stahl, G. (Ed.). (2009) *Studying Virtual Math Teams*, Springer, Boston.
- Toulmin, S., (1958). *The Uses of Arguments*. Cambridge Univ. Press.
- Trausan-Matu, S., Dessus, P., Rebedea, T., Mandin, S., Villiot-Leclercq, E., Dascalu, M., Gartner, A., Chiru, C., Banica, D., Mihaila, D., Lemaire, B., Zampa, V., Graziani, E., *Learning Support and Feedback, LTfLL Deliverable 5.2*, http://ltfll-project.org/tl_files/LTfLL-Deliverables/LTfLL_D5.2.pdf, downloaded at November 7, 2010
- Trausan-Matu, S., & Rebedea, T. (2010). A Polyphonic Model and System for Inter-animation Analysis in Chat Conversations with Multiple Participants. In A. Gelbukh (Ed.), *Computational Linguistics and Intelligent Text Processing* (Vol. 6008, pp. 354-363): Springer Berlin / Heidelberg.

Acknowledgments

The research presented in this paper was partially funded by the projects no. 212578, FP7-ICT-2007-1-4.1 LTfLL (<http://www.ltfll-project.org/>) and project no. 264207, FP7-REGPOT-2010-1 ERRIC - Empowering Romanian Research on Intelligent Information Technologies (<http://erric.eu>). The authors would like to thank all the students and tutors at the University "Politehnica" of Bucharest that were involved in the validation experiments.

Social Cues in Asynchronous Online Discussions: Effects of Social Metacognition and New Ideas

Gaowei Chen, University of Pittsburgh, gac28@pitt.edu
Ming Ming Chiu, State University of New York at Buffalo, mingchiu@buffalo.edu
Zhan Wang, The Hong Kong Institute of Education, wangzhan@ied.edu.hk

Abstract: This study examines how group members' social metacognition and new ideas in recent messages affected a current message's positive social cue (SC) or negative SC during asynchronous, online discussions. We modeled 894 messages by 183 participants regarding 60 high school mathematics topics (typically 8 people posted per topic) on a public, informal, mathematics problem solving website not connected to any class or school (www.artofproblemsolving.com) with a statistical discourse analysis. Results showed that group members' agreements facilitated positive SCs, while disagreements facilitated negative SCs. Meanwhile, new ideas and justifications were less likely to be accompanied by SCs. Together, these results suggest that teachers can foster student's construction of knowledge by encouraging polite disagreements during online collaborative learning.

Introduction

Students are increasingly using asynchronous, online discussions to aid their learning (Tallent-Runnels et al., 2006), in part because these discussions allow people to collaborate at different places and times—unlike traditional face-to-face (FTF) discussions. Researchers have focused on cognition during online discussions rather than social relationships (De Wever, Schellens, Valcke, & Van Keer, 2006). Moreover, researchers have not systematically examined the relationships among online discussion messages to characterize group processes that affect the likelihood of online SCs. SCs can indicate online authors' (*users*) affective states and attitudes toward others, which could in turn affect their social relationships and collaboration (Swan & Shih, 2005).

In this study, we take a step in this direction by examining how social metacognition and new ideas in recent messages facilitate or hinder a current message's positive SC or negative SC during online mathematics discussions. By understanding how users' discussion processes affect their use of SCs, educators can help students develop positive social relationships that aid their online collaboration and reduce negative SCs that may harm their collaborative learning (Garrison, Anderson, & Archer, 2000).

Theoretical Perspective

Positive vs. Negative SCs

The SCs in a discussion are not necessarily related to the problem content (Henri, 1992). Specifically, positive SCs can display users' positive affective states (e.g., "Oh, I get it now"; "☺") or show their positive attitude toward others when giving greetings, emphasizing agreement (e.g., "I *totally* agree with you!"), or showing appreciation (Brown & Levinson, 1987). Such positive SCs can help build a mutually respectful, supportive, and encouraging climate that promotes positive social relationships and collaboration in the problem content space (Garrison et al., 2000).

In contrast, negative SCs show users' negative affective states (e.g., "I'm so stupid"; "☹") or negative attitude toward others, such as rudeness ("You are wrong!!!") and flaming ("No, I'm not, YOU are wrong!!!"; Herring, 1994). Such negative SCs might create an aggressive or hostile environment that harms users' social relationships and hinders their collaboration. In this study, we examine how social metacognition, new ideas, and SCs in recent messages affect a current message's positive or negative SCs.

Social Metacognition and New Ideas

Like FTF discussants, users often use social metacognitive strategies to evaluate one another's ideas (agreement, disagreement, or neutral), recognize problems, and invite audience participations (question, command, or statement). When agreeing with previous ideas, users are likely to add positive SCs to emphasize their positive feeling and enhance their positive social relationship. For example, when agreeing with an idea, users who feel strongly about it might add extra affective words (e.g., "Aha, I agree with you") or emoticons (e.g., "Right ☺"), which parallel smiling agreements in FTF discussions. By emotionally supporting a previous idea, users enhance their solidarity and make the text-based discussion more enjoyable. Meanwhile, as agreements often indicate positive social relationship (Brown & Levinson, 1987; Chiu, 2008b), a user responding to an agreement is more likely to continue the positive social relationship (Walther, 1992), usually by adding a positive SC in the response.

In contrast, when users disagree with previous ideas, they might be less likely to add positive SCs in their messages. In online discussions, the anonymity and reduced face concerns allow users to disagree with one another more freely (Reinig & Mejias, 2004). Thus, users might be less likely to use positive SCs to soften or redress disagreements; or they might even add negative SCs to disagree rudely due to the reduced normative constraints of online discussions (e.g., adding exclamations, “No, you are wrong!!!”).

Compared to FTF discussions, the larger pool of potential participants and the asynchronous nature of online discussions reduce the expectation that any one specific participant must respond any time soon or respond at all. Thus, users are likely to use a *negative politeness* strategy to reduce imposing on the target person to give him or her more freedom (*negative politeness* redresses the imposition of the speaker on the listener and is often used to make a request less infringing, e.g., “Could you...”; “It’s kind of off-topic...”; Brown & Levinson, 1987). By using such positive SCs to express a question politely, users are likely to increase the possibility of receiving a satisfactory response.

Users are less likely than FTF discussants to use SCs when providing new ideas. Unlike FTF discussants, online users often do not know each other and have weaker social commitments, resulting in greater psychological distance among them (Chen & Chiu, 2008). Furthermore, online discussions filter out the nonverbal channels that are generally rich in interpersonal information. By focusing more on the problem content and less on the social relationships, they are likely to use fewer SCs in their new ideas. Likewise, as justifications (i.e., justified new ideas) facilitate calm, reason-based communication (Chiu, 2008a), users might focus more on the problem content rather than on their social relationships; hence, justifications are less likely to be accompanied by SCs.

In short, agreements might facilitate positive SCs, while disagreements might hinder them during online discussions. Meanwhile, questions are likely to increase positive SCs in the responses. Also, new ideas and justifications are likely to reduce the likelihood of SCs during online discussions.

Control Variables

Other factors such as users’ previous recent positive and negative SCs, users’ personal information (displayed gender [masculine, feminine, or neutral], number of past posts, initiator of topic), message number (bigger number indicates later posting), message length (number of words per message), and time interval between messages were entered as control variables.

Method

Participants and Data

In this study, 183 users discussed 60 mathematics problems in the High School Basics (HSB) forum on the Art of Problem Solving website (www.artofproblemsolving.com). Participants can communicate with one another as they wish, without teacher moderation or control. The target audience for the forum is students aged 12–16 from across the world.

Sixty mathematics problems were randomly selected from the HSB forum, excluding problems with less than 4 reply messages. These 60 problems received 894 reply messages. Each problem and its reply messages were linked to one another by multiple threads and single connections. See Table 1 for example messages responding to a mathematic problem.

Variables & Coding

In this study, the unit of analysis was the complete message posted on the online discussion. Variables for a single message included message number, message length, time interval between messages, user’s number of past posts, and the following binary variables: agreement, disagreement, correct new idea, wrong new idea, new idea with unknown validity, justification, repetition, question, command, positive SC, negative SC, masculine, feminine, and initiator of the discussion topic.

Two students coded each message separately. Then, they settled all coding disagreements by consensus. The analyses use two sets of variables: current variables measuring properties of the current message (0) and lag variables measuring properties of earlier messages in the same thread ($-n$, where $n = 1, 2, 3, 4$). See Table 1 for coding examples.

Analyses

Statistical Discourse Analysis (SDA; Chiu, 2008a; Chiu & Khoo, 2005) separated unexplained error into message (level one) and topic (level two) components, thereby removing the correlation among error terms resulting from messages nested within topics. A Logit model properly models the binary outcome variable positive SC or negative SC. We used an alpha level of .05 for all statistical tests. Benjamini, Krieger, and Yekutieli’s (2006) two-stage linear step-up procedure was used to control for the false discovery rate. We used Higgins and Thompson’s (2002) I^2 index to modify the Ljung-Box Q statistics (Ljung & Box, 1979) for testing

serial correlation in the residuals of the regressions for all topics (Huedo-Medina, Sanchez-Meca, Marin-Martinez, & Botella, 2006). To facilitate the interpretation of these results, we converted the total effects (E) of each explanatory variable to odds ratios, indicated by the percentage increase or decrease (+E% or -E%) in the likelihood of an outcome variable (Kennedy, 2003).

Table 1: Coding of an online discussion segment on the problem: “how do you find x in $x^2 + 3x = 40$?”

# ^a	IC ^b	Message	SC ^c	EPM ^d	IF ^e	NI ^f	J ^g	R ^h
1.	Sue; F; 1103	I got -8, 5. Try to factor with this formula: $ax^2 + bx + c =$ $a(x - \frac{-b + \sqrt{b^2 - 4ac}}{2a})(x - \frac{-b - \sqrt{b^2 - 4ac}}{2a})$	N	*	-	√	J	T ⁱ
2.	Jim; M; 107	I checked with the formula, -8 and 5 are correct :-)	☺	+	-	R	~	1
3.	Sue; F; 1103	Thanks, Jim.	☺	+	-	N	N	2
4.	Leo; M; 2379	You made it tooooooo complicated!	☹	-	-	N	N	1
5.	Sue; F; 1103	What is your way of solving the problem?	N	*	?	N	N	4

^a Message number in time order. ^b Individual characteristics (IC): *nickname*, displayed gender (masculine [M], feminine [F], or no gender-identifying characteristics [N]), and the number of past posts. ^c Social cues (SC): positive SC [☺], negative SC [☹], no SC [N]. ^d Evaluation of the previous message (EPM): Agreement [+], disagreement [-], ignore/neutral [*]. ^e Invitational form (IF): statement [-], question [?], command [!]. ^f New ideas (NI): correct, new idea [√], wrong, new idea [X], new idea with unknown validity [U], repetition [R], no mathematics content [N]. ^g Justification: justification [J], no justification [-], no mathematics content [N]. ^h Responding to which message. ⁱ Topic message.

Results & Discussion

The multi-level variance components model showed that the users' positive SCs and negative SCs did not differ significantly across topics, so single-level analyses at the message level were adequate. The inter-rater reliabilities as measured by Krippendorff's α for evaluation, invitational form, new ideas, and SCs were 0.89, 0.92, 0.85, and 0.93 respectively (corresponding percentages of agreement were 90%, 97%, 93%, and 96%). For both positive SCs and negative SCs, the final model's Q -statistics and I^2 index showed no significant serial correlation of residuals for the 60 topics up to lag 3. Thus, the time-series model was likely appropriate.

Evaluations Increase SCs

Users' evaluations were linked to more SCs in this study. Agreement (0) in the current message increased a positive SC's likelihood in the same message (+18%; when an agreement did not occur, a positive SC in the same message occurred 19% of the time; when an agreement occurred, a positive SC in the same message occurred 37% of the time; see Table 2 and Figure 1). Agreement (-1) in the previous message also increased a positive SC's likelihood in the current message (+10%). These results supported the agreement hypothesis.

Agreements in the current messages (0) and the previous messages (-1) increased the likelihood of positive SCs in the current messages (0), showing that users were likely to use positive SCs both in their own agreements and in responding to others' agreements. The results also suggest that users might distort their content via agreement to aid social relationships. Future research can test the validity of this claim.

In contrast, disagreement (0) reduced a positive SC's likelihood (-8%), supporting the disagreement hypothesis. Moreover, disagreements increased the likelihood of a negative SC (+16%). These results show that users tended not to use positive SCs to help others save face by disagreeing politely; on the contrary, they often used negative SCs to disagree rudely (face attack, Tracy & Tracy, 1998). The reduced face concern and increased psychological distance of users might have inclined them to post more offensive comments and aggressive messages. This result contrasts with that of FTF discussion studies, in which group members often disagree politely to help save face during disagreements (Brown & Levinson, 1987; Chiu, 2008a).

New Ideas Reduce SCs

Unlike evaluations, users' new ideas and justifications were linked to fewer SCs in this study. Correct new ideas, wrong new ideas, and new ideas with unknown validity reduced a negative SC's likelihood (-13%, -15%, and -9%, respectively), supporting the new idea hypothesis. A correct new idea, wrong new idea, or new idea with unknown validity in a current message reduced the likelihood of a negative SC, suggesting that users' new ideas, regardless of the type, not only provided useful information for problem solving but reduced negative SCs that might threaten their social relationships and collaboration.

Table 2: Total effects of each explanatory variable on positive SC (0), negative SC (0), and explanatory variables.

Explanatory variable (E)	Target (T)	P(T E) (%) ^a	P(T ~ E) (%) ^b	Effect (%)
(1) Message number (0)	positive SC (0)	23	19	+4 ^c
(2) Initiator (0)	positive SC (0)	37	19	+18
(3) Agreement (0) ^d	positive SC (0)	37	19	+18
(4) Disagreement (0) ^d	positive SC (0)	11	19	-8
(5) Justification (0)	positive SC (0)	12	19	-7
(6) Agreement (-1)	positive SC (0)	29	19	+10
(7) Disagreement (0)	negative SC (0)	36	20	+16
(8) Correct new idea (0) ^e	negative SC (0)	7	20	-13
(9) Wrong new idea (0) ^e	negative SC (0)	5	20	-15
(10) New idea with Unknown validity (0) ^e	negative SC (0)	11	20	-9
(11) Agreement (0)	Justification (0)	18	31	-13
(12) Agreement (-1)	Disagreement (0)	26	44	-18

^a Probability that the target occurs, given that the explanatory variable does occur.

^b Probability that the target occurs, given that the explanatory variable does *not* occur.

^c The +4% effect is explained by a 50% increase above the mean of a message's number.

^d The baseline value for comparison is a neutral evaluation. See Kennedy (2003) for details.

^e The baseline value for comparison is a null content or repetition message.

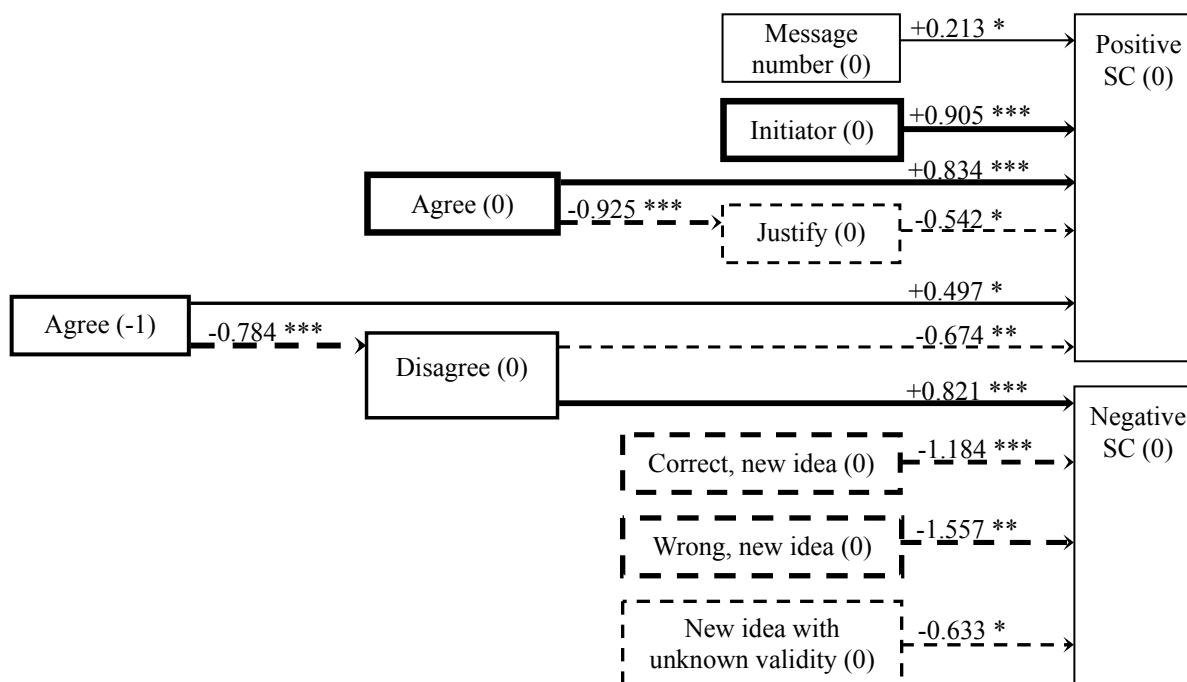


Figure 1. Path analysis of significant explanatory variables of positive SC (0) and negative SC (0) using two-level Logit. Values are standardized parameter coefficients. Solid boxes and arrows (→) indicate positive effects, dashed boxes and arrows (---) indicate negative effects, and thicker lines indicate larger effect.

Meanwhile, a justification reduced the likelihood of a positive SC (-7%), supporting the justification hypothesis. This result shows that when providing justifications that might often involve higher cognitive demands, users tended to focus more on the problem content space and used fewer positive SCs for developing social relationships. Justifications were linked to fewer SCs, supporting the claim that justifications facilitate less emotional, reason-based discussions (Chiu, 2008a).

Implications for Researchers

This study modeled conceptual relationships among online discussion messages to explore links between characteristics of recent messages with a new statistics method. These results suggest three implications for researchers involving social metacognition, public online forums, and statistical methods. First, this study highlighted social metacognition, as agreements and disagreements in the previous and current messages

influenced the likelihood of SCs in the current message. These results suggest that researchers consider how social metacognition fits into a comprehensive theoretical framework of online collaborative learning (in addition to new ideas and justifications).

Second, this study examined high school students' interactions on a public, online forum unrelated to any academic course and hence free from any course evaluation. Researchers can compare students' discussions in non-course-related forums with those in course-related forums to obtain a more comprehensive understanding of students' online behaviors. Third, this study used a new methodology for analyzing online discussion processes by modifying SDA (Chiu, 2008a; Chiu & Khoo, 2005). Moreover, we quantified the heterogeneity of the n topics by creating an I^2 index that compares the Q value with its expected value when assuming homogeneity (Huedo-Medina et al., 2006).

Implications for Teachers and Forum Designers

The results have practical implications for teachers and forum designers. The focus on content during online discussions is desirable, but disagreements were often accompanied by negative SCs in un-moderated forums. Hence, teachers can encourage students to evaluate one another's ideas carefully, thereby reducing false disagreements that might yield negative SCs. Furthermore, this suggests an important role for a teacher: fostering polite disagreements during online discussions. By doing so, students are likely to reduce rude rejections that might harm their social relationships and online collaborative learning.

As users often used negative SCs when disagreeing, forum designers can place fewer ready-to-use negative emoticons (e.g., emoticons expressing anger or attack) on the toolbar. By doing so, users are less likely to insert negative emoticons to express their impulsive negative feelings when disagreeing. (Note that users can still use positive emoticons sarcastically or to be mean, e.g., "I'm so much smarter than you ☺".)

References

- Benjamini, Y., Krieger, A. M., & Yekutieli, D. (2006). Adaptive linear step-up procedures that control the false discovery rate. *Biometrika*, *93*, 491-507.
- Brown, P., & Levinson, S. C. (1987). *Politeness*. New York: Cambridge University Press.
- Chen, G., & Chiu, M. M. (2008). Online discussion processes. *Computers & Education*, *50*(3), 678-692.
- Chiu, M. M. (2008a). Flowing toward correct contributions during group problem solving. *Journal of the Learning Sciences*, *17*(3), 415-463.
- Chiu, M. M. (2008b). Effects of argumentation on group micro-creativity. *Contemporary Educational Psychology*, *33*, 382-402.
- Chiu, M. M., & Khoo, L. (2005). A new method for analyzing sequential processes. *Small Group Research*, *36*, 1-32.
- Chiu, M. M., & Kuo, S. W. (2009). From metacognition to social metacognition. *Journal of Education Research*, *3*(4), 1-19.
- De Wever, B., Schellens, T., Valcke, M., & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education*, *46*(1), 6-28.
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment. *The Internet and Higher Education*, *2*(2-3), 87-105.
- Herring, S. C. (1994). Politeness in computer culture. In *Cultural performances* (pp. 278-294). Berkeley, CA: Berkeley Women and Language Group.
- Henri, F. (1992). Computer conferencing and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing* (pp. 115-136). New York: Springer.
- Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine*, *21*, 1539-1558.
- Huedo-Medina, T. B., Sanchez-Meca, J., Marin-Martinez, F., & Botella, J. (2006). Assessing heterogeneity in meta-analysis. *Psychological Methods*, *11*, 193-206.
- Kennedy, P. (2003). *A guide to econometrics*. Cambridge, MA: MIT Press.
- Krippendorff, K. (2004). *Content analysis*. Thousand Oaks, CA: Sage.
- Ljung, G., & Box, G. (1979). On a measure of lack of fit in time series models. *Biometrika*, *66*, 265-270.
- Reinig, B., & Mejias, R. (2004). The effects of national culture and anonymity on flaming and criticalness in GSS-supported discussions. *Small Group Research*, *21*(6), 698-723.
- Swan, K., & Shih, L. F. (2005). On the nature and development of social presence in online course discussions. *Journal of Asynchronous Learning Networks*, *9*(3), 115-136.
- Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., Cooper, S., Ahern, T. C., Shaw, S. M., & Liu, X. (2006). Teaching courses online. *Review of Educational Research*, *76*(1), 93-135.
- Tracy, K., & Tracy, S. J. (1998). Rudeness at 911. *Human Communication Research*, *25*, 225-251.
- Walther, J. B. (1992). Interpersonal effects in computer-mediated interaction. *Communication Research*, *19*(1), 52-91.

PolyCAFe: Collaboration and Utterance Assessment for Online CSCL Conversations

Mihai Dascalu, Traian Rebedea, Stefan Trausan-Matu, University “Politehnica” of Bucharest,
313 Splaiul Independentei, 060042 Bucharest, Romania
Email: mihai.dascalu@cs.pub.ro, traian.rebedea@cs.pub.ro, stefan.trausan@cs.pub.ro
Gillian Armit, University of Manchester, Higher Cambridge Street, Manchester, M15 6FH, UK,
gillian.armit@manchester.ac.uk

Abstract: Students and members of communities of practice are often using online conversations to enhance their knowledge and skills. Although there have been a lot of efforts to find an efficient method for analyzing this type of discussions, most of the research has been mostly theoretical or has not been transformed into software due to technological limitations. This paper presents PolyCAFe, a system built for providing feedback to students that use chats and forums for solving their learning tasks. Moreover, the system can also be used by tutors to supervise or to support students. Starting with the theoretical fundamental aspects of the system, the paper continues with an insight in the technologies used behind PolyCAFe’s design and ends with an overview of the first validation experiment.

Introduction

Instant messenger (chat) is already used for several years in Computer Supported Collaborative Learning (CSCL) sessions (Stahl, 2006). However, there are very few systems designed for automatically analyzing such conversations, but also capable of generating feedback. The explanation is probably founded on the aspect that Natural Language Processing is required and that the existing technologies in Computational Linguistics are still not mature, especially for analyzing chat conversations, which have many important differences as compared to non-conversational text.

Several CSCL systems were developed for analyzing interactions in conversations (face-to-face or virtual through chat) and forums. Some examples are CORDTRA (Hmelo-Silver, Chernobilsky, & Masto, 2006), COALA (Dowell & Gladisch, 2007), DIGALO and other tools used in the Argonaut system (Harrer, Hever, & Ziebarth, 2007), ColAT (Avouris, Fiotakis, Kahrimanis, & Margaritis, 2007), TATIANA, (Dyke, Lund, & Girardot, 2009), the Scaffold-Argument visualization (Law, Lu, Leng, Yuen, & Lai, 2008), KSV (Teplovs, 2008), VMT-Basilica (Kumar, Chaudhuri, Howley, & Rosé, 2009) and Polyphony (Trausan-Matu, Rebedea, Dragan, & Alexandru, 2007).

Some of the aforementioned systems are using different kinds of argumentation graphs (Toulmin, 1958), more elaborated structures like the contingency graphs (Suthers, Dwyer, Medina, & Vatrupu, 2007) or polyphonic threads visualization in Polyphony. Almost all the systems provide only facilities for manual annotation and input of links and of visualization. No system excepting PolyCAFe, the system presented in this paper, provides complex facilities for chat and forum discussions’ analysis and gives useful feedback for learners and tutors.

In our opinion there are several causes that might explain this situation. The first one is that even if Bakhtin’s dialogism is considered a theoretical model of CSCL (Koschmann, 1999; Stahl, 2006), except our own system we don’t know of any actual implementation based upon it. The second cause is related to the fact that the majority of collaborations in CSCL are based on the exchange of text messages. Thus, another problem arises from the fact that current Natural Language Processing (NLP) systems are far from providing reliable text understanding systems. Moreover, in CSCL chats and forums there are usually more than two participants and the floor might be shared by more than a single participant at a given moment in time, a case which is generally not considered in most NLP theories developed for conversation analysis (Trausan-Matu & Rebedea, 2010).

PolyCAFe is based on an integration of NLP, social network analysis and polyphonic analysis (Trausan-Matu & Rebedea, 2010). Its first version was developed and validated under the LTfLL FP7 project (<http://ltfll-project.org>) and it is currently under change to version 2.0. However, all the results presented in this paper are about PolyCAFe 1.0.

The paper continues with section 2, which presents some concepts of Bakhtin’s dialogism that represent one of the central theoretical bases of PolyCAFe. Section 3 briefly presents the technologies behind the system, its main features, while key results from the first validation experiments with the system are depicted in section 4. The paper ends with several points on transferability and conclusions

The Core Concepts of Bakhtin's Dialogism

Our analysis is centered on three different, but inter-dependent concepts: *utterances* briefly defined as units of analysis, *voices* as distinctive points of view emerging from the ongoing discussion and *echo* as the replication of a certain voice with further implications in the discourse.

Utterances and Discussion Threads

Utterances can be defined as pieces of text whose boundaries are represented by the change of speech subject (Bakhtin, 1986) and embed the central unit of analysis of the discussion. Utterances express both acts of communication and pieces of discourse (Linell, 2009) and direct the path and evolution of the ongoing conversation in terms of future development. Our analysis adheres to Dong's perspective of separating utterances based on turn-taking events between speakers (Dong, 2005).

A central aspect that needs to be addressed is the meaning of each utterance within a given context, in our case a discussion thread derived from the utterance graph. The utterance graph is built upon two types of links between utterances: explicit and implicit ones (Dascalu, Rebedea & Trausan-Matu, 2010). Participants can manually add explicit links during their chat sessions by using a facility of the VMT chat environment (Stahl, 2009) we used. On the other hand, implicit links are automatically identified by means of co-references, repetitions, lexical chains, inter-animation patterns and semantic similarity (Trausan-Matu & Rebedea, 2010). In the resulted directed and acyclic graph, each utterance is a node and the weights of edges are given by the similarity between the utterances, multiplied by the trust assigned to each link. The orientation of each edge follows the timeline of the chat and the evolution of the discussion in time. Starting from the previous graph, a discussion thread can be easily identified as a logical succession of explicitly or implicitly inter-linked utterances. Moreover, the primary extension of each utterance is its inner voice that intertwines with other voices from the same thread or from different ones, but with less strength. A new intervention or a new utterance in terms of units of analysis can be clearly expressed as a voice and the following aspects that need to be addressed include: coherence, degree of interconnection with other previous utterances, relevance within the discourse and future impact in the overall discussion.

Voices

A voice expresses a distinct position, a point of view, even an utterance or an event with further influence in the conversation. All preconditions are met by assuming that each utterance is read or heard, remembered and further discussed, therefore having an impact in the discourse (Trausan-Matu & Rebedea, 2009). Moreover, a voice may be expressed as a perspective or topic (Linell, 2009) of a singular participant or of a group sharing a similar insight on the topical domain. With regards to a single individual, he may adhere, personalize and express several different voices by interacting with other people based on his formal background, education and attitude towards the topic at hand. Therefore, besides internal voices embedding personal perspectives and external voices uttered by other individuals and expressing the influence of others on one's opinion, generalized voices emerge to which a larger group of people consent.

In order to benefit mostly from collaboration, the main goal of the discussion can be defined in terms of voice inter-animation and the aim becomes achieving true polyphony (Bakhtin, 1993). Polyphony is closely related to the musical concept from which it was derived and encapsulates multiple points of view and voices. Dostoevsky's work presents conflicting views, not just various angles and multiple perspectives, not just a single, all-knowing and overwhelming vision common among most writers; all these aspects should also be covered in a truly collaborative conversation.

Echoes

A context is a slice of a discussion thread characterized by high internal cohesion and rather loose coupling with other parts of the conversation. A central voice emerges from a context, brings cognitive and creative significance and by its evolution in time models the unfinalized potential of that specific context (Bakhtin, 1986). The relation is bi-univocal in the sense that a context can encapsulate multiple voices and by merging all perspectives, the context can be defined.

The echo of a specific voice represents its replication in time with enough strength to influence other voices in one or more contexts. Two types of echoes can be identified: individual ones when a participant internalizes a voice and collective echoes when multiple participants react to a voice, enriching the context.

After analyzing all core concepts, two major effects were identified and taken into consideration in our analysis. Firstly, a retrospective, synergic effect, based on overlapping voices from previous utterances and their corresponding echoes, models and influences the current utterance in a given context. Secondly, a prospective effect expresses further implications in the discussion thread with regard to own personal echoes and models the context, highlighting the unfinalizable, dialogic nature of the discussion.

Summing all previous remarks, we can conclude that collaboration is based on voice intertwining and inter-animation and that one of the purposes of our system is to highlight and assess interaction between

participants in a collaborative environment. The next section addresses the technological aspects and the actual implementation of some of the previous concepts centered on the assessment process of utterances.

Technologies and Computational Perspective

Technically, PolyCAFe combines Natural Language Processing (NLP) and Social Network Analysis (SNA). Its main tasks are implicit link detection starting from patterns, repetitions and semantic distances based on WordNet and LSA (Trausan & Rebedea, 2010), utterance evaluation and collaboration analysis based on the utterance graph and the scores for the utterances. As results, the system provides feedback on several distinct levels: for each utterance in the conversation, for each participant and for the conversation as a whole.

The presentation of the feedback to the users is done in simple web widgets that can be used independently or together and can be integrated into most online learning environments (Rebedea et al., 2010). There are widgets for each level of feedback discussed above, plus two helper widgets:

- The *conversation feedback widget* presents statistics about the whole chat: the most frequent synsets, the most relevant concepts that are present in the chat and in the domain specific corpora used for training the LSA, a suggestion of concepts from the semantic space that are semantically similar to the ones discussed in the chat (that might be seen as the concepts that are in the zone of proximal development for the current conversation) and statistics regarding the density of the utterance graph, percent of personal opinions and argument, etc.
- The *participant feedback* offers assessment for each participant on several levels: relevance with regards to the domain corpora, social presence and importance, coherence, etc.
- The *utterance feedback* gives indicators on the value of each post: speech acts and argumentation patterns that are present in the utterance, plus a social and semantic score.
- The *conversation visualization* is a helper widget that contains an intuitive display of the utterance graph and the collaboration graphics as shown in Figure 1.
- The *search conversation widget* provides a mechanism for ranking utterances and participants with regards to a search query and by taking into consideration not just the lexical items, but also the semantic relations and the importance of each utterance as considered by the utterance evaluation process.

Validation Experiment and Results

A first validation experiment has been performed at a Human Computer Interaction course, involving 9 senior (4th year) students and 5 tutors that used PolyCAFe for analyzing the conversations and providing feedback to the students. The experiment was structured in the following way: the students had to document on a given topic using online and printed materials and then they had a debate using VMT chat system in two small groups of 4-5 students. After the debate, they used PolyCAFe's widgets to understand their actual role in the conversation and what could have been improved. This activity was monitored by two tutors that provided help to the students and took notes on how they used the widgets. This activity lasted between 90-120 minutes and was followed by a questionnaire with 32 validation statements with answers on a 5-level Likert scale (1-strongly disagree, to 5-strongly agree). The tutor validation experiment followed a similar scheme. Tutors were asked to provide feedback to a chat conversation using PolyCAFe and to the another without the system. After this step, they were invited to answer a questionnaire with 35 validation statements.

Both validation experiments have been promising, with very encouraging results as can be seen in Table 1. For a better understanding of the collected results, the statements have been divided into five categories: pedagogical effectiveness, efficiency, cognitive load, usability and satisfaction.

Table 1: The validation results for the tutors and student experiments.

Validation statement category	Tutor average score	Tutor percentage agreement	Student average score	Student percentage agreement
Pedagogic effectiveness	4.11	83%	3.94	77%
Efficiency	5.00	100%	4.22	78%
Cognitive load	4.60	100%	3.56	56%
Usability	4.36	93%	4.11	81%
Satisfaction	4.57	91%	3.89	72%
TOTAL	4.53	93%	3.94	73%

For the questionnaires, the tutors have agreed with all but one of the statements with average scores between 3.50-5.00/5.00. It is clear that all the tutors find the system efficient for their task as it helps them

reduce the time needed for providing their own feedback to the students. It is easily noticeable that the students' results are worse for all categories than the ones of the tutors. The lowest score was obtained for cognitive load showing that the users had some problems accommodating to the system on their first use. This high cognitive load might have influenced the results for all other categories. As in the tutor experiment, the highest average score was also reached for effectiveness showing that the system provides feedback that helps them understand better the characteristics of their conversation. However, the lower scores obtained for effectiveness and satisfaction prove that the feedback is not easily interpretable by the students, enabling them to improve their future learning activities. Moreover, the results show that more than a quarter of learners are not satisfied by the system and the main reason for this score was that the students do not trust the results offered by the system as it employs statistical methods and it has also provided some wrong indicators for a few utterances in their conversations. Considering each validation statement in particular, the students agreed with 27 out of the 32 statements with average scores between 3.56-5.00. As it can be noted from the results presented above, there are some serious differences between the results for students and those of the tutors. Another conclusion that can be extracted from these facts is that tutors might have overrated the system due to the fact that it helps them provide feedback more quickly and effectively.

Conclusions and Transferability

In this paper we have introduced PolyCAFe, a system designed for providing feedback and support for learners that use online discussions in their learning activities. Starting from the theoretical underpinning of dialogic and polyphonic theories, the system uses NLP and SNA processing in order to discover implicit relations between utterances and builds an utterance graph that is then used for utterance evaluation and collaboration assessment.

The system has also been used in a formal education context for validating its utility and the validity of the feedback provided to users. The results of the first validation experiment are encouraging, but highlight that tutors are considering PolyCAFe more useful and relevant for their task than the students. The transferability of the system involves three aspects: domain, language and learning task. The system needs all the tools that form the NLP pipe, plus an open-data WordNet or, at least, a dictionary. The domain transferability is mostly concerned with the existence of a serious corpus for training the latent semantic spaces (preferably, made up of online conversations or titles plus abstracts for forums). Any learning task that can be easily expressed in writing and involves open argumentations or problem solving is suitable for being analyzed by PolyCAFe. However, the system is not designed for tasks that make use of scripted collaborations.

References

- Avouris, N., Fiotakis, G., Kahrmanis, G., & Margaritis, M. (2007). Beyond Logging of Fingertip Actions: Analysis of Collaborative Learning Using Multiple Sources of Data. *Journal of Interactive Learning Research*, 18, 231–250.
- Bakhtin, M.M. (1986). Speech genres and other late essays, *University of Texas*, Austin.
- Bakhtin, M.M. (1993). Problems of Dostoevsky's Poetics, Edited and translated by Caryl Emerson, *University of Minnesota Press*, Minneapolis.
- Dascalu, M., Rebedea, T. & Trausan-Matu, S. (2010). A Deep Insight in Chat Analysis: Collaboration, Evolution and Evaluation, Summarization and Search, *AIMSA 2010*, LNAI 6304, 191-200, Springer.
- Dascalu, M., Trausan-Matu & S. Dessus, Ph. (2010). Utterances Assessment and Summarization in Chat Conversations, *Special Issue on Natural Language Processing and its Applications*, Mexico, 46.
- Dong, A. (2005). The latent semantic approach to studying design team communication, *Design Studies*, 26(5): 445-461.
- Dowell, J., & Gladisch, T. (2007). Design of argument diagramming for case-based group learning. *ACM International Conference Proceeding Series; Vol. 250*, 99–105.
- Dyke, G., Lund, K., & Girardot, J.-J. (2009). Tatiana: an environment to support the CSCL analysis process. *Computer Support for Collaborative Learning*, 58–67.
- Harrer, A., Hever, R., & Ziebarth, S. (2007). Empowering researchers to detect interaction patterns in e-collaboration. *Frontiers in Artificial Intelligence and Applications; Vol. 158*, 503–510.
- Hmelo-Silver, C. E., Chernobilsky, E., & Mastro, O. (2006). *Representations for Analyzing Tool-mediated Collaborative Learning*. Proceedings of ICLS 2006, New Brunswick.
- Koschmann, T. (1999). *Toward a dialogic theory of learning: Bakhtin's contribution to understanding learning in settings of collaboration*. In CSCL'99, Palo Alto.
- Kumar, R., Chaudhuri, S., Howley, I., & Rosé, C. P. (2009). VMT-Basilica: an environment for rapid prototyping of collaborative learning environments with dynamic support. *Computer Support for Collaborative Learning*, 192–194.
- Law, N., Lu, J., Leng, J., Yuen, J., & Lai, M. (2008). *Understanding Knowledge Building from Multiple Perspectives*. Proceedings of Workshop on Interaction Analysis, ICLS 2008.
- Linell, P. (2009). Rethinking language, mind, and world dialogically, *Information Age Publications*, Greenwich.

- Rebedea, T., Dascalu, M., Trausan-Matu, S., Banica, D., Gartner, A., Chiru., C. & Mihaila, D. (2010). *Overview and preliminary results of using PolyCAFe for collaboration analysis and feedback generation*. Proceedings of EC-TEL 2010, LNCS 6383, 420-425, Springer.
- Stahl, G.: (2006). *Group Cognition: Computer Support for Building Collaborative Knowledge*, MIT Press.
- Stahl., G. (Ed.). (2009) *Studying Virtual Math Teams*, Springer, Boston.
- Suthers, D., Dwyer, N., Medina, R., & Vatraru, R. (2007). *A framework for eclectic analysis of collaborative interaction*. Proceedings of Computer Support for Collaborative Learning 2007.
- Teplovs, C. (2008). *The Knowledge Space Visualizer: A Tool for Visualizing Online Discourse*. Proceedings of the International Conference of the Learning Sciences 2008.
- Trausan-Matu, S., & Rebedea, T. (2009). Polyphonic inter-animation of voices in VMT. In Stahl, G. (ed.), *Studying virtual math teams*, pp. 451-473, Springer, New York.
- Trausan-Matu, S., & Rebedea, T. (2010). A Polyphonic Model and System for Inter-animation Analysis in Chat Conversations with Multiple Participants. In A. Gelbukh (Ed.), *Computational Linguistics and Intelligent Text Processing*, Vol. 6008, pp. 354-363, Springer.
- Toulmin, S. (1958). *The Uses of Arguments*: Cambridge Univ. Press.

Acknowledgments

The research presented in this paper was partially funded by the projects no. 212578, FP7-ICT LTfLL (<http://www.ltfll-project.org/>) and project no. 264207, FP7-REGPOT-2010-1 ERRIC (<http://erric.eu>).

Analysis of Group Understanding in Artifact-Mediated Discourses

Heisawn Jeong, Hallym University, Chuncheon, Korea (South), heis@hallym.ac.kr
Wenli Chen, National Institute of Education, Singapore, wenli.chen@nie.edu.sg
Chee-Kit Looi, National Institute of Education, Singapore, cheekit.looi@nie.edu.sg

Abstract: A collaborating group is increasingly viewed as a cognitive unit, the workings of which need to be understood independent of its effects on individual learning. We are beginning to understand how groups operate as a cognitive unit that learns, solves problems, and/or constructs new knowledge, but still lack adequate conceptual frameworks and analytic strategies to deal with different dimensions of group cognition. This problem is particularly acute in small group interaction mediated by technologies. While various technological tools are used to support small group interaction, we do not understand clearly yet how group understanding emerges from this process. In this paper, we examined the development of group understanding when the group discourse is mediated by the construction of technological artifacts.

Introduction

While interest in collaborative learning initially started as a way to promote students' individual learning, a collaborative group is increasingly viewed as a cognitive unit, the workings of which need to be understood independent of its impact on individual learning (Stahl, 2010; van Aalst, 2009). In real life, small group function as a unit of information processing in team performance (e.g., ship navigation), knowledge production (e.g., research teams), and creativity (e.g., theatrical production). Treating the group as a unit means more than using it as a unit of coding and analysis. It means that a group needs to be considered as an agent whose properties are independent from its individual members (Hutchins, 1995). It consists of individuals, but its characteristics and behaviors may not necessarily follow those of its individual members. In this paper, we define group understanding as what the group knows as a whole and explore how it develops over time through interaction.

Small group interaction is typically mediated by verbal discourse. Existing discourse analysis methods heavily rely on the analysis of verbal discourse data. However, with the advent of information technology, collaboration is increasingly mediated by various technological tools. In this paper, we explored the development of group understanding when their interaction was mediated by technology. We take the artifacts group constructs as a proxy for group understanding (Jeong, in press) and examined how group understanding, in the form of contributions to the group workspace, evolved over time as its members share their ideas, elaborate on each other's contributions, and make sense of the different conceptions arising from the discourse.

Research Context and Data Sources

The data were drawn from a school-based research project about classroom collaborative knowledge building practices through the routine use of a networked technology called GroupScribbles (GS). A fifth grade class (about age 11) in a primary (elementary) school in Singapore participated in the project. In one of the activity called as "Fraction Division," students were asked to work out a ratio when dividing two pizzas equally among three children. The objective of the lesson was to understand the concept of ratio as a way to show the relative sizes of the two quantities, to understand that a given ratio does not indicate the actual size of the quantities involved, and to draw a comparison model to represent the two quantities given the ratio. Students worked in groups of four. They were first asked to work individually, either thinking about the solution or creating their private notes, and then to share it with the rest of the group. Members of the group were expected to discuss their individual solutions within the group and to arrive at some consensus. Students were also expected to interact with other groups. The GS tool provides workspaces for students in the form of private and public boards presented in a two-paned window. The lower pane of the GS was the user's personal workspace or private board where students worked individually. The upper pane of the GS was the group boards or public workspace. Students could create posts in their private space, and then move them to the group space where they can be viewed and commented by other students. Students could also access the public spaces of other groups and copy and publish notes (see Looi et al., 2010, for more detailed description of the curriculum and the technologies).

There were ten groups in the class. We randomly chose one group, Group 2, as our target group. The target group comprised of four students: Terry, Victor, Helen, and Quentin (all pseudonyms). Although they did not face each other, they sat in pairs over two rows and thus could talk to the student seated next to them. One video camera was set behind the classroom to record the whole classroom, while another camera recorded the target group. A screen capturing software was installed on each student's Tablet PC and recorded students' on-

screen activities, verbal utterances, facial expressions, and non-verbal behaviors. The activity lasted about 16 minutes.

Analyses

An earlier analysis of this data was carried out from the perspective of uptake analysis (Looi & Chen, 2010). In this paper, we examined the data from the perspective of how group understanding develops through artifact-mediated discourse. Our analyses focused on the following two issues. First, we examined the development of group understanding with respect to the solution to the ratio problem. This was done based on the analysis of the artifacts students created during the activity, that is, the contents of the group workspace. We analyzed the kinds of contributions students made in the group's public space and traced how it has changed over time. Second, we analyzed the discourse around the artifacts to identify how verbal utterances and non-verbal activities in the GS environment have contributed to the construction of the artifacts.

Artifacts: Postings and Contributions

Most of students' contributions to the group space consisted of post-it notes in the form of drawing or texts. Once published, postings can interact in that students can publish notes related to what others have already contributed. In order to identify postings that 'interacted', we grouped individual postings into contributions. While *postings* refer to individual notes or drawings that students published, *contributions* refer to a set of postings grouped around the same core ideas. Additions, improvements, and revisions of the existing posting were considered as one contribution. For example, if a student put a check mark on top of existing drawing (indicating approval of the drawing) or if a student divided the pizza in certain ways and then put a post-it with the same drawing on top of the existing drawing, they were considered to belong to the same contribution. Contributions may consist of single posting, if there was no follow-up posting, or of several different postings. Using the videos and transcripts, we examined and identified postings students created during the activity. Both task-related and task-unrelated (e.g., packmen drawings) contributions were coded. The authors of the contributions were also coded. Whenever there is a change in the contents of the group workspace, we coded it as a separate state of the group space and coded the contributions involved in the change. A state change typically involved an addition or removal of a single posting, but could involve multiple postings as multiple students often published and/or arranged notes in the group space at the same time.

Artifact-Mediated Discourse: Verbal and Non-verbal Activities

In GS environments, discourse not only consists of verbal activities but also non-verbal activities. Verbal activities refer to utterances either directed to oneself or to other students. Non-verbal activities refer to gestures, behaviors (e.g., raising hands to get attention; glancing at other students' screen) or actions in GS environment (e.g., actions such as publishing and trashing of notes, drawing and erasing of drawing, moving and rearranging notes were all coded as relevant activities). In order to examine how these discourse activities contributed to the construction of artifacts, we identified verbal and non-verbal activities that occurred around each contribution. There were a number of off-task or task-unrelated activities in the transcript and the video such as talking about one's speaker and starting off the GS program. Such activities were not coded unless they were related to one of the contributions identified in the artifacts coding. For each activity, we coded the 'owner' of the activities.

Results

Evolution of the Group Space

Group space evolved steadily as students added contributions to the group space. Thirteen contributions were made to Group 2's public space. The group space started with two blank pizzas (Figure 1a), but quickly grew into a state with several contributions including some task-unrelated contributions (Figure 1b and 1c) and to its final state (Figure 1d).



Figure 1. Evolution of the Group 2's Public Space.

Including the initial and final states, the group workspace has undergone 61 different states. Figure 2 shows when each contribution first appeared and/or disappeared over the 61 states (the break toward the end

indicates a computer crash). The group space that began with zero contribution in the beginning contained six contributions (C2, C3, C4, C6, C9, & C13) at the end (State 61). After initial postings were made, contributions underwent some changes throughout the episode. These involved reworking and revision of one's own posts, publishing of comments on existing contributions, or rearranging of posts, and in some cases, removal of posts. For example, a contribution (C6) appeared early on in the episode (State 9), disappeared later from the public space when the student wanted to make a change in the post (State 51) but soon reappeared (State 53), and remained in the group space till the end. The contribution (C1) stayed in the group board over two states, but quickly disappeared. Of the 13 contributions published in Group 2's public space, slightly less than half of them (46%) remained in the public space till the end. Most of the contributions disappeared were task-unrelated contributions, but two of the task-related contributions also disappeared from the group space. In one case (C7), an unidentified student made an 'accidental' contribution in Group 2's group space, but removed it quickly (State 16 & 17). In another case (C12), Helen published a post with two circles each divided by four (State 27). It was not a correct solution. It appears that she was trying things out and removed the post because she was unsure about it (State 29).

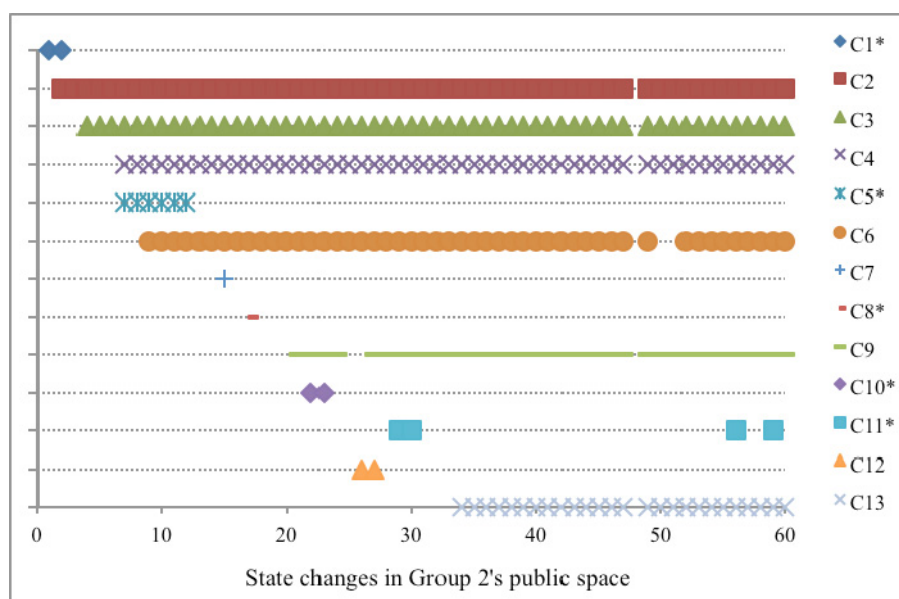


Figure 2. Contributions in the group workspace (Contributions with asterisk were task-unrelated contributions).

Emergence of the Contributions

Contributions emerged through artifact-mediated discourse, often over many activity sequences. For example, the last contribution in the Group 2's workspace (C13) was made by Helen when she checked on another group's work. Helen was checking out other groups' workspaces and noticed a colored pie drawing (Figure 3a). Since she did not know how to put color to pie charts, she copied the drawing and published it in her group's workspace. She did not alter the drawing except changing the color of the note from orange to green. She put "I borrowed" note on top of her drawing, indicating that she did not come up with the solution herself. This 'borrowed' contribution later received a few feedbacks (e.g., "nice", "great colours") from other students (Figure 3b).

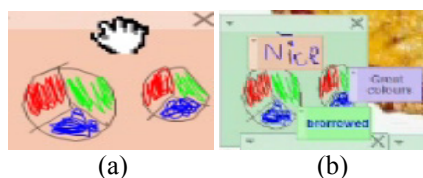


Figure 3. (a) The posting that Helen took from Group 1a's public workspace. (b) Helen's contribution to her own group's workspace at the end of the episode.

To be precise, this contribution emerged from the following sequence of activities (Helen also posted "I borrowed" and "thx" to Group 1's public space, but they were not included in the analysis since they were contributions outside of Group 2's space):

1. Helen went to Group 1a's public space and saw a posting with 3 different colors (Figure 3a).
2. Helen said: "Wow, how did they color it?"

3. Helen took the post from Group 1a's public space to her private workspace.
4. Helen cloned the post.
5. Helen put the post back to Group 1a's public space.
6. Helen changed the color of the cloned post in her private workspace from red to blue.
7. Helen moved the post to her own group's public workspace.
8. [pause] An unidentified student (from another group) put a comment "nice" on top of her post.
9. [pause] Helen posted a little post saying "I borrowed" on top of her post.
10. Another unidentified student put a comment "Great colours." (Figure 3b)

For each of the contributions in Group 2's public space, we examined how it has evolved over time. As can be seen in the above example, contributions emerged from both verbal and non-verbal activities. That is, unlike typical discourse, the interaction in GS environment was mediated both verbally and non-verbally through what the students posted in the public space. On average, about one third of the contributions (29%) were verbal in the form of self-talks or dialogues, and the rest (71%) were non-verbal activities in GS environments (Table 1). It appears that non-verbal activity, mostly in GS actions, supplemented the need for talk and became the dominant mode of discourse.

Table 1: Mean verbal and non-verbal activities per contribution.

Contributions	All	Activities	
		Verbal	Non-verbal
Task-related (N=8)	11.13	3.63 (33%)	7.50 (67%)
Task-unrelated (N=5)	12.00	3.00 (25%)	9.00 (75%)
All (N=13)	11.46	3.38 (29%)	8.08 (71%)

Contributions not only evolved over multiple activities but also over multiple contributors. Contributions in Group 2's workspace were examined in terms of who has carried out the individual activities that contributed to them. If only one student's talk or activities were involved in the evolution of the contribution, it was considered as individualistic contributions. If more than one student was involved, then the contribution was considered to be collaborative. In the case of contribution in Figure 3 (C13), for example, it was considered as a collaborative contribution because Helen got her post off of another group's space and also because of the comments made by two unidentified students. Of the 13 contributions in Group 2's public space, more than half (54%) were individualistic contributions and the rest (46%) were collaborative contributions (Table 2). Task-related contributions tended to be more collaborative than task-unrelated contributions. There was one task-unrelated contribution that was collaborative. It occurred when one student in Group 2, Victor, got bored and posted several "MINE" notes all over the group board. When other students saw these posts, they grabbed and trashed them, saying "get rid of mine". Thus, they did not participate in his off-task behavior, but instead collectively censored his disruptive postings in order to regulate the group board.

Table 2: Frequency (percentage) of individualistic and collaborative contributions.

	Individualistic	Collaborative
Task-related (N=8)	3 (38%)	5 (62%)
Task-unrelated (N=5)	4 (80%)	1 (20%)
All (N=13)	7 (54%)	6 (46%)

Task-related contributions tended to be collaborative. However, while they were collaborative in the sense that students talked about them and posted evaluative comments and feedback about the contributions, the quality of the interaction remained on the shallow side. Students would put question marks or check marks on others' postings, but substantive comments were rare. In addition, questions and comments were not followed through, so that question marks or comment such as "there are two pizzas" (about a post with only one pizza) went on unanswered. Similarly, relationships between different solutions were never discussed. Solutions in the form of drawings and formulas were not integrated. Students did not organize their public knowledge except for occasional rearrangement of posts. It should be noted, however, that the whole activity lasted 16 minutes, not enough time for such interactions to unfold.

Discussions

In this study, we examined how group understanding can be assessed when interaction involves the construction of artifacts. We took the artifacts created by the group as a proxy for the group understanding and examined how it evolved over time. The results showed that group understanding, as reflected in the contents of the group space, experienced changes as individuals share their ideas, elaborate on each other's contributions, and make

sense of the different conceptions arising from the discourse. Contributions, once made, were subject to comments and revisions, and in some cases removal. While the understanding evolved to include several correct solutions to the problem, the ‘quality’ of the group understanding was not high. For the group to develop its understanding, the group needs to engage in accommodation as well as assimilation (Cress & Kimmerle, 2008). In this study, the students actively shared and interacted over postings. In the process, the group assimilated different knowledge and the group representation grew in size. However, the group did not carry out much reorganization or synthesis of the knowledge they assimilated. Little accommodation occurred, and as a result, group understanding remained fragmented, mostly as a collection of individual contributions.

The analysis also examined how each contribution emerged from artifact-mediated discourse. The majority of the contributions were collaborative, but the collaboration was mediated by both verbal and non-verbal activities in the GS workspaces. Although students interacted verbally over contributions, the majority of the interaction occurred in the form of comments and checkmarks on the contributions. As they could respond by posting comments and notes, there was less need to interact verbally. Dillenbourg and Traum (2006) examined grounding and problem solving in a multi-modal computer mediated learning environment. They examined how a shared white board and a chat tool in MOO environment were used for grounding and noted that acknowledgement rate varied across media and content. They reported that the whiteboard was used to represent the state of the problem and the chat was used to ground information (Dillenbourg & Traum, 2006). While the present study involves different modalities and tools, it appears that when interaction is distributed over different modality and media, different media may take on different roles in interaction (Chen, Looi, & Tan, 2010). More research is needed to understand how artifact-mediated discourse might differ from verbal discourse and the role different technologies may serve in this process.

In summary, the work reported in this paper provided a descriptive account of interaction of a collaborative group activity in the context of a real classroom lesson. In this environment, the discourse was mediated by GS artifacts and often took the form of activities as students responded to other students’ contributions by providing additional artifacts. Tools such as GS can support the construction of group understanding a great deal. It supports students’ cognitive interactions by making the artifacts visible and persistent so that everybody can easily see what has been accomplished by all members (Chen, et al., 2010). Group accomplishments build on the individual contributions. A small contribution by an individual, while it may appear insignificant by itself, can further the progress of the group in critical ways. In this study, we provided an analysis of how group understanding evolved from the interactions between students and between students and artifacts. As we carried out our analysis, we feel that we are encroaching into a space where there are enormous conceptual and methodological challenges and opportunities and urge other researchers to participate in this exciting process of advancing our understanding about group cognition.

References

- Chen, W., Looi, C. K., & Tan, S. (2010). What do students do in a F2F CSSL classroom? The optimization of multiple communications modes. *Computers & Education*, 55(3), 1159-1170.
- Cress, U., & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *Computer-Supported Collaborative Learning*, 3, 105-122.
- Dillenbourg, P., & Traum, D. (2006). Sharing solutions: Persistence and grounding in multimodal collaborative problem solving. *The Journal of the Learning Sciences*, 15(1), 121-151.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: The MIT Press.
- Jeong, H. (in press). Verbal data analysis for understanding interactions. In C. Hmelo-Silver, A. M. O'Donnell, C. Chan & C. Chinn (Eds.), *The International Handbook of Collaborative Learning*. London: Taylor and Francis.
- Looi, C. K., & Chen, W. (2010). Community-based individual knowledge construction in the classroom: a process-orientation account. *Journal of Computer Assisted Learning*, 26(3), 202-213.
- Looi, C. K., Chen, W., & Ng, F. K. (2010). Collaborative activities enabled by GroupScribbles (GS): An exploratory study of learning effectiveness. *Computers & Education*, 54, 14-26.
- Stahl, G. (2010). Group cognition as a foundation for the new science of learning. In S. K. Myint & I. M. Saleh (Eds.), *New science of learning: Cognition, computers and collaboration in education*.
- van Aalst, J. (2009). Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourse. *International Journal of Computer-Supported Collaborative Learning*, 4, 259-287.

Acknowledgments

This research was in part funded by the National Research Foundation of Korea (Grant No. 2009-0068919) awarded to the first author and the National Research Foundation of Singapore (Grant No. 2007-IDM003-MOE-001) to the second and third authors. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Research Foundations of Korea and Singapore.

Investigating Students' Epistemologies in CSCL Discourse through Reflective Judgment Model and Practical Epistemologies

Johnny Yuen, University of Hong Kong, Hong Kong, johnny@cite.hku.hk

Abstract: Students' beliefs in knowledge and knowing has been studied from different theoretical underpinnings for decades; however, researchers still have difficulties in explaining students' epistemic dynamics in socio-constructivist discourse from epistemological perspectives, e.g. Why some students demonstrate high level epistemic dynamics more frequently than others? This study aims to investigate this phenomenon from two theoretically different perspectives in research on students' epistemology: reflective judgment model and practical epistemologies. Thirty-two grade 8 students' epistemology was measured with King & Kitchener's (2004) reflective judgment model; at the same time Chinn & Malhotra's (2002) "epistemic authenticity" framework was employed to analyze students' practical epistemologies in essays. Analysis was focused on possible relationship between students' epistemological beliefs and their practical epistemologies demonstrated through engagements in computer supported collaborative inquiries discourse. Preliminary findings show students operate at more advanced levels of personal epistemology might be more inclined to engage in CSCL discourse as a socio-constructivist one.

CSCL: Socio-constructivist Discourse for Learning

Computer Supported Collaborative Learning (CSCL), a branch of the learning sciences deeply rooted in socio-constructivist theories, concern with studying how people can learn together for the benefit of increased learning capacity and outcome with the help of computers. In the literature, different socio-constructivist learning theories discern unique forms of learner-discourse dynamics and possible outcome. For example Vygotsky's social learning theory focuses on enhancement of learner's potential with mediation of a more capable peer through language and thoughts within the zone of proximal development. Piagetian socio-cognitive conflict describes the importance of creating disequilibrium in the learner's mind from interactions with others towards accommodation or assimilation of concepts. Situated cognition, like cognitive apprenticeship in Communities of Practice (CoP) (Lave & Wenger, 1991) identifies a specific form of socio-constructivist socialization process where learning of tacit knowledge and social norms specific to a community can only be achieved through legitimate peripheral participation within the socio-cultural environment. Last but not least Collaborative Knowledge Building (KB) (Bereiter & Scardamalia, 2005) explains the social origin of new knowledge or progression of ideas and theories, through knowledge works that treat knowledge as semi-autonomous artifacts that could be worked on collaboratively like real artifacts. To summarize, different socio-constructivist theories outline different forms of socio-constructivist interactions and dynamics between learners and the discourse; hence, post different assumptions and expectations on the engagements from their participants. Suggested by Kanselaar (2002), individual's engagement in socio-constructivist learning environments involves at least three aspects of learners' epistemological beliefs, including 1) nature of knowledge, 2) beliefs about learning and cognition, and 3) pedagogical beliefs about the best way to support learning. Kanselaar (2002) argues that variations among these aspects of beliefs form a "loosely coupled system" that serves as the basis of learners' epistemic engagement and potential outcome in socio-constructivist learning.

Reflective Judgment and Socio-constructivist Dynamics in CSCL

Personal epistemology is the field of research that specializes in investigation of one's beliefs in knowledge and the knowing process, and characteristics of people's epistemic behavior. King & Kitchener's reflective judgment model (RJM) (2004) describes a complex network of developmental progression of epistemological assumptions that late adolescents and adults rely on for making judgments about ill-structured controversial issues that cannot be solved by formal logic alone from four epistemic dimensions, including nature of knowledge, concept of justification, role of authority, and role of evidence, which is suitable to be applied to investigate learner-discourse epistemic dynamics in socio-constructivist discourses. The reflective judgment model describes seven levels of increasing sophistication in reflective thinking reasoning styles, which, could be summarized into three broad categories: pre-reflective, quasi-reflective, and reflective thinking. In pre-reflective thinking (stage 1-3 of RJM), people believe knowledge is gained through authorities or firsthand observations; while they believe what they know is absolutely correct and certain, no justification is required. In quasi-reflective thinking (stage 4-5 of RJM), people reason with assumptions that knowledge claims contain elements of uncertainty, thus tend to view judgments as highly idiosyncratic. In reflective thinking (stage 6-7 of RJM), people accept that knowledge claims cannot be made with certainty, so any judgments could only be "most reasonable" and "reasonably certain" based on a variety of interpretive considerations. Conclusions thus are

defended as representing the most complete, plausible, or compelling understanding on the basis of available evidence, of which Zeidler et al. (2009) argue are consistent with nature of science (NOS) claims.

Student's Practical Epistemologies in Socio-constructivist Discourse

Argued by many (e.g. Bereiter & Scardamalia, 2005; Sandoval, 2005; Zeidler et al., 2009), mature scientific inquiry works resemble socio-constructivist epistemic dynamics in many ways. Sandoval (2005) suggests investigating 'practical epistemologies' that students bring into situations of inquiries. Practical epistemologies are highly contextualized epistemological ideas that students develop from their practical experiences through attempts to make sense and explain the world they live in; thus these epistemological ideas would re-surface in students' subsequent scientific inquiries. Sandoval (2005) suggests students' practical epistemologies could be evaluated by the epistemological authenticity framework (Chinn et. al, 2001; 2002), which argues the underlying structure of authentic scientific inquiries are fundamentally different from scientifically unauthentic ones in terms of connections that link ideas and inquisitive acts together. In brief, Chinn et al. suggested four kinds of epistemic connections to be varied between authentic and un-authentic inquiries; they are causal, inductive, analogical, and contrastive connections. Chinn et al. (Chinn & Brewer, 2001; Chinn & Malhotra, 2002) illustrated that the kind and combination of epistemic connections involved in scientifically authentic and unauthentic inquiry tasks are very different.

Other than epistemic connections, some researchers approach argumentative discourse acts in socio-constructivist learning discourses from the perspective of informal reasoning, arguing informal reasoning are as important as formal logic towards scientific progression (Sadler, 2004; Zeidler et al., 2009). Law, Yuen, Wong & Leng (2011) have investigated students' use of argumentative and question discourse markers in collaborative knowledge building discourses, and found qualitative and quantitative differences in the usage of discourse markers between inquiry threads which has and has not achieved idea progressions.

Summary & Research Questions

To summarize, socio-constructivist learning theories explains how collaborative learning happens through outlining different forms of socio-constructivist interactions and discourse dynamics between learners and the cultural environment. Specific theories post specific assumptions and requirements on participants' beliefs on knowledge, learning process, and desirable epistemic dynamics. As a result, investigating CSSL participants' beliefs on knowledge and knowing, and whether their epistemic engagement match with those outlined in specific learning discourse would greatly inform researchers about the question why some students would demonstrate high level epistemic dynamics more frequent than others? This study proposes and investigates the possible relationship between students' epistemology and their epistemic engagements in a socio-constructivist learning discourse, i.e. whether students who have more advanced epistemological beliefs be more inclined to engage in the CSSL discourse as a socio-constructivist one.

Context of Study & Methodology

This study investigates 32 grade 8 students' epistemic engagements in a learning module of integrated humanities conducted over 15 weeks. The curriculum design of the module reflects the school's strong emphasis on developing students' epistemic developments through collaborative inquiry learning, like deepening of students' understanding on the tentative and improvable nature of knowledge, and inquiry as a theory building process. The activity of the learning module is "planning of building a new tourist attraction for Hong Kong", where four stages of on and offline activities were designed by the teacher and the researcher towards students' understanding on *idealism and materialism*, two theories that explain development of civilizations. In this learning module, Knowledge Forum (KF) was used as the online collaborative platform to facilitate discourse dynamics. Three sources of data have been collected and analyzed to investigate the possible relationship between students' epistemological beliefs and epistemic engagements in the online discourse.

First, students' level of personal epistemology was measured by a questionnaire instrument designed by the author, based on the reflective judgment model by King & Kitchener in a format similar to the Reasoning for Current Issues (RCI) test (King & Kitchener, 2004). Two tests with topics related to the module (ecological footprint and natural/cultural conservation) have been designed and both distributed as pre and post test. Individuals' levels of reflective judgment (RJ) as measured from pre and post tests were calculated from students' choices and ranks to the items.

Qualitative analyses have been conducted on logs of Knowledge Forum® discussions to investigate students' usage of argumentative and questioning speech acts (Law, Yuen, Wong & Leng, 2011). The speech acts and related specific discourse markers used in the analysis are:

Category	Speech act	Discourse markers coded
Argumentative	Claim	I think, I agree, we should
	Disagreement	I don't think, I didn't think, I do not think, I don't agree, ...
	Reason	because, since
	Elaboration	moreover, such as
	Condition	if
	Contrast	but, though, although, however, even, otherwise
Question	Consequence	then, thus, so, therefore
	Explanatory	how, why
	Factual	what, is there, are there, where, who, whom

By the end of the learning module students have to hand in individual essay on their view towards idealism and materialism. The teacher has introduced a writing framework for the essay. This essay is a class work, and students have 2 one-hour lessons to finish it. Students' usages of epistemic connections in the essay, e.g. causal, inductive, analogical, and contrastive (Chinn & Malhotra, 2002) have been analyzed and coded:

Analysis & Results

Figure 1 presents one possible interpretation of data collected. In the figures, students are sorted by their measured level of reflective judgment from post test, from low to high.

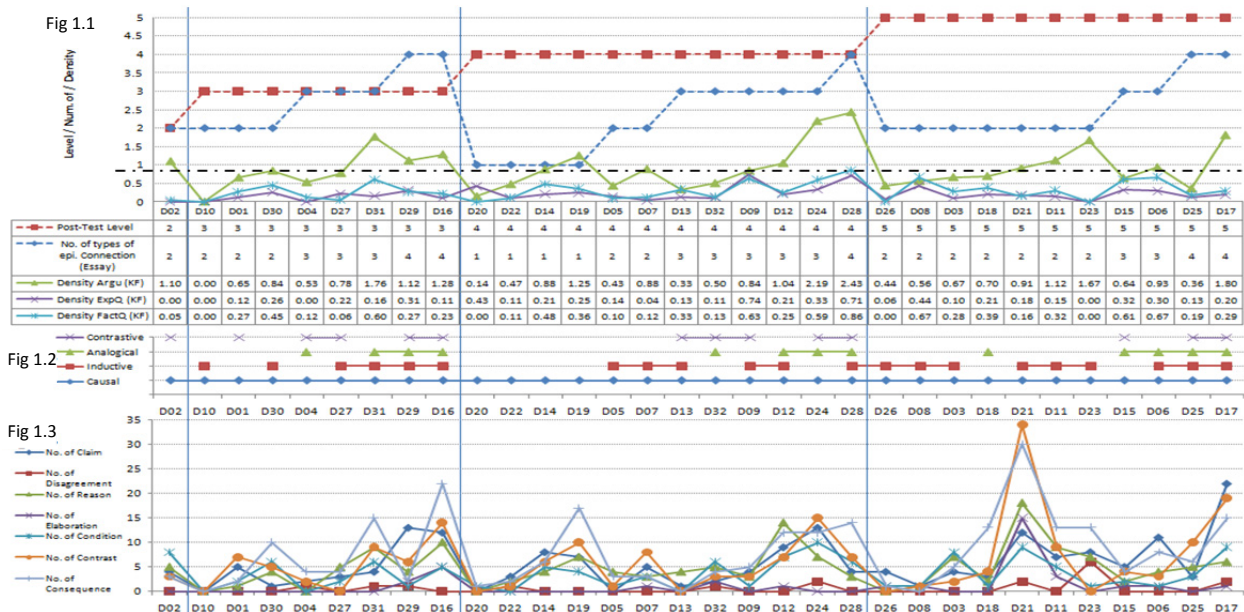


Figure 1.1. Measured level of reflective judgment from post test; Number of types of epistemic connection used in students' final essay, & Densities of argumentative and question discourse markers; Figure 1.2. Types of epistemic connection used in students' final essay; Figure 1.3. Breakdowns of individual's usage of argumentative and question markers in numbers.

Students' Epistemology Approached as Separated Perspectives

Figure 1.1 presents data of individual students from all three sources of data collected. The first is the level of reflective judgment from post test (red dashed line with squares). Cronbach alpha of pre and post test of questionnaire instrument is 0.784. The second is the number of types of epistemic connections used in student's module essay (blue dashed line with diamonds), which informs epistemic authenticity of students' inquiry in their essay. From figure 1.1, only 5 students (D16, D17, D25, D28, & D29) have used all four types of epistemic connections in their essay. Figure 1.2 present breakdowns of types of epistemic connection found in individual student's essay. From the plot, causal is the most common type of connections found in students' essays.

The third group of data presented in figure 1.1, densities of argumentative and question discourse markers used by individual students in his/her notes on the KF, are conceived as indicative of students' informal reasoning at inquiry and engagement in the CSCL discourse. In general, students' densities of argumentative markers (green line with triangles) are higher than densities of both question markers (light blue & purple lines).

Table 1: Mean densities of markers by students' measured post test levels.

Post Test Level	No. of students	Mean den. of Argu markers	Mean den. of Expl Q markers	Mean den. of Fact Q markers
Pre-reflective (2-3)	9	0.89	0.13	0.23
Quasi-reflective (4-5)	23	0.92	0.24	0.33
Class Median	32	0.84	0.17	0.27

Interestingly, students who operated at quasi-reflective thinking in post test (level 4-5) have higher mean density of argumentative and question markers in their KF postings than students at pre-reflective levels

(level 2-3) (table 1). At the same time, in general students who have used more types of epistemic connections also have higher densities of argumentative or question markers, e.g. student D31, D24, D28, D17. In general, positive relationship exists between mean densities of argumentative markers used on KF and number of epistemic connection used in students' essay (table 2).

Table 2: Summary of mean densities of three categories of discourse markers.

No. of types of epistemic connection used in essay	1	2	3	4
No. of students	4	13	10	5
Mean density of Argu markers used in KF	0.69	0.77	0.95	1.4
Mean density of ExplQ markers used in KF	0.25	0.13	0.25	0.29
Mean density of FactQ markers used in KF	0.24	0.22	0.40	0.37

Figure 1.3 offers an expanded view on the number of each kind of argumentative speech acts identified from individual student's postings on the KF. From the chart, no student's usage and pattern of argumentative speech act is similar to each other. In general, students who have higher than class median density of argumentative markers (figure 1.1 black dash dotted line) tend to use more number of claims, contrast and consequence speech acts, while patterns could hardly be perceived among students who have lower than class median density of argumentative marker.

Students' Epistemic Dynamics in CSSL Discourse and Individual Essays

The three vertically aligned charts (figure 1.1-1.3) afford to be read vertically for profile view of individual student's epistemology from the three sources of data. Table 3 summaries and put them in groups according to three criteria: 1) Density of argumentative markers in students' postings on KF, 2) Pre and post test difference in level of reflective judgment, 3) Number of types of epistemic connection used in final essay.

First of all, there are certain degrees of similarities among students who have used all four types of epistemic connections in their essay. Five students, D29, D16, D28, D25, & D17 belong to this category. In terms of measured level of reflective judgment between pre and post tests, results show two out of the five students have increased level of reflective judgment, two decreased and one held constant (table 3); still, all of them have operated at level 4 (quasi-reflective) or above in either pre or post test. Also, except student D25, they all have higher than class median (0.84, black dash dotted line, figure 1.1) density of argumentative markers in KF discussions. Furthermore, breakdowns of their usage of argumentative markers are quite similar (*claims*, *contrast* or *consequence*) upon close examination (figure 1.3).

Table 3: Relationship between measured RJ and density of markers.

Density of Argu Markers	Pre & post tests diff. in levels of RJ	No. of epistemic connection used				Total
		1	2	3	4	
Above or equal to class median 0.84	Increase	1	2	2	1	6
	Constant	-	3	1	1	5
	Decrease	1	1	2	2	6
Below class median 0.84	Increase	2	2	-	1	5
	Constant	-	3	2	-	5
	Decrease	-	2	3	-	5
Total		4	13	10	5	32

On the other hand a group of four students have used "causal" connection only to connect ideas in their final essay, including students D20, D22, D14 & D19. Although all of their measured level of reflective judgment are at level 4 (quasi-reflective) from the post test, in fact three students have increased and one has decreased from their previous levels (table 3). In details, their engagements on the KF are quite different among themselves. Student D14 & D19's densities of argumentative and question markers are above class medians, while for D20 & D22 the relevant densities are all below class medians. Usages of argumentative markers also distinguish the two pairs from each other. For student D14 & D19, *claim*, *consequence* and *contrast* are the top three most used markers. On the contrary, there are barely any argumentative markers used by student D20 & D22 in the KF discourse.

For students who have used 2-3 types of epistemic connections in essay, there are almost equal numbers of students who have higher (11 students) or lower (12 students) than class median density of argumentative markers on KF (table 3). Students who have higher than class median density of argumentative markers in 2-3 connection-types groups (e.g. student D31, D12, D24, D06) tend to have used larger number of *claim*, *contrast*, *reason* and *consequence* markers, similar to students who have high argumentative markers density in the 4-types group. Furthermore, usage of kind and number of argumentative markers are very different between them (figure 1.3).

Discussions

In this exploratory study possible relationship between students' epistemic beliefs and practical epistemologies brought into socio-constructivist discourse and essays have been studied from 1) Measured changes in level of reflective judgment, 2) Densities, number and types of argumentative markers used in KF, and 3) Numbers and types of epistemic connections used in final essay.

First of all, the assumption of a possible relationship between students' level of reflective judgment and epistemic dynamics in socio-constructivist discourse was shown to be positive at preliminary level. In this exploratory study, data from questionnaire and KF suggest that students who operate at quasi-reflective thinking levels (4-5) of reflective judgment have higher mean densities of argumentative and questions markers (table 1) than students who operate at pre-reflective thinking levels (2-3). To explain the differences, King and Kitchener's reflective judgment model suggest that people who operate at pre-reflective thinking believe what they know and think are absolutely correct and certain hence no justification is required, while people at quasi-reflective thinking levels hold the beliefs that knowledge claims contains elements of uncertainty and idiosyncrasy. As a result, students at quasi-reflective levels see greater needs in making sense out of uncertainties in others' claims and ideas on the CSCL discourse, while students at levels 2-3 do not treat such sense-making acts as their primary concern in the collaborative learning discourse.

On the other hand students' uses of argumentative markers as process indicators also show its functions in the investigation of student epistemology in socio-constructivist discourses. Argued by Chinn et al. (2001; 2002), the more scientifically authentic an inquiry task is, the more kinds of epistemic connections could be found to connect or link ideas, procedures and experimental conditions together that meets scientific standards. In this study individual students who have used more types of connections in essay were found using a higher density of argumentative markers in KF (table 2 & figure 1.1), suggesting students may see the CSCL discourse as venue for epistemic engagements towards a progressive discourse somewhat similar to scientific inquiry. The findings also inform Sadler's (2004) argument for the importance of informal reasoning in collaborative discourses to scientific inquiry progresses.

To summarize, preliminary findings of this study show that students who operate at more advanced levels of personal epistemology in the reflective judgment test instrument and personal essay might be more inclined to perceive and engage in the online CSCL discourse as a socio-constructivist one, as reflected from usages of discourse markers. However, these findings are far from conclusive towards the question posted at the beginning. The methodology applied is inadequate in terms of breath of indicators and depth of analysis to obtain a fuller picture of individual's network of reflective judgment beliefs from complex stage theory (King & Kitchener, 2004) point of view. Further, there are possibilities students hold context specific epistemological beliefs that lead to different epistemic behaviors in different learning discourses. Last but not least, the coding scheme on types of epistemic connections applied to students' essays could be further enriched to capture more specific usage of words or argumentative markers. Certainly more in depth research on these are required.

References

- Bereiter, C., & Scardamalia, M. (2005). Beyond Bloom's Taxonomy: Rethinking knowledge for the Knowledge Age. In M. Fullan, *Fundamental Change: International Handbook of Educational Change* (pp. 5-22). Springer Netherlands.
- Chinn, C.A., & Brewer, W.F. (2001). Models of Data: A Theory of How People Evaluate Data. *Cognition & Instruction*, 19(3), 323-393.
- Chinn, C. A., & Malhotra, B. a. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, 86(2), 175-218
- Kanselaar, G. (2002). Constructivism and socio-constructivism. From < <http://scholar.google.com> > (Retrieved Nov 2, 2010).
- King, P. M., & Kitchener, K. S. (2004). Reflective Judgment: Theory and Research on the Development of Epistemic Assumptions Through Adulthood. *Educational Psychologist*, 39(1), 5-18.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Law, N., Yuen, J., Wong, W., & Leng, J. (2011). Understanding learners' knowledge building trajectory through visualizations of multiple automated analyses. In S. Puntambekar, G. Erkens, & C. E. Hmelo-Silver (Eds.), *Analyzing interactions in CSCL: Methods, issues and approaches*. NY: Springer.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41(5), 513-536.
- Sandoval, W.A. (2005). Understanding students' practical epistemologies and their influence on learning through inquiry. *Science Education*, 89(4), 634-656.
- Zeidler, D. L., Sadler, T. D., Applebaum, S., & Callahan, B. E. (2009). Advancing reflective judgment through Socioscientific Issues. *Journal of Research in Science Teaching*, 46(1), 74-101.

Recommender Systems: A Technology to Foster Individual and Collaborative Learning

Jürgen Buder, Christina Schwind, Knowledge Media Research Center, Konrad-Adenauer-Str. 40,
72072 Tübingen, Germany
Email: j.buder@iwm-kmrc.de, c.schwind@iwm-kmrc.de

Abstract: Recommender systems are used to provide people with personalized information on items that might be of interest to them. There is a growing attention in the learning sciences to employ recommender systems for fostering learning processes. While recommender systems have some features that resonate well with principles in the learning sciences, it is evident that specific adaptation of recommender systems is needed in order to foster individual and collaborative learning. It is argued that in order to make recommender systems valuable tools in educational contexts, the design of these systems should address tensions between system characteristics, individual characteristics, educational characteristics and group characteristics.

Introduction

When we ponder over the movie that we'd like to see next weekend, or want to find out whether the new restaurant in town is worth checking out, we often rely on the experience and recommendations of friends and other people who we trust to be knowledgeable about our tastes and preferences. Recommendations are based on social judgments, i.e. cognitive activities where an individual evaluates whether an item such as a movie or a restaurant is liked or not (Sherif & Hovland, 1961). While social interaction with others often involves sharing one's social judgments, it needs an additional element to turn a judgment into a recommendation: This element is adaptation. In order to be able to adapt a social judgment, a communicator must know about the tastes and interests of a recipient (Wegner, 1987). If this knowledge is available, one can recommend an item even in cases where one's individual social judgment is different. For instance, one could recommend a movie to a friend irrespective of one's own judgment because the friend's favorite actor stars in it.

Recommendations provide a person with valuable cues, thereby giving guidance to one's activities. The larger the space of options, the more it becomes important to have valuable recommendations at hand. Navigating through information spaces like the WWW represents an activity where the number of available options can become exceedingly large. In order to deal with the huge amounts of information, people would benefit from having access to other persons' social judgments, or even better, to receive social judgments that are adaptively tailored to their personal interests. Consequently, many Web environments leave ample room for people to share social judgments: by encouraging customers to write reviews on products, rate items, or discuss them with others. Often, individual social judgments are accumulated over people to arrive at averaged social judgments of an entire collective, as in the case of bestseller lists. However, none of these methods takes the particular interests of a user into account; they lack the adaptive elements of personalization. This is where recommender systems come into play. Out of individual social judgments from users, mostly in the form of item ratings, they compute personalized recommendations that are adapted to a given user (Herlocker, Konstan, Terveen, & Riedl, 2004).

A common method employed to generate personalized recommendations is through collaborative filtering (Herlocker et al., 2004). Collaborative filtering relies on the input of a collective of users, and for each user the system stores behavioral data. This can be accomplished through implicit feedback like user clicks and reading times, or through explicit feedback in the form of user ratings. Similarity metrics between users or between items are then used to generate recommendations for a user.

Users of recommender systems do not directly interact with each other. Thus, their behavior cannot be regarded as collaborative, but rather as collective, i.e. they autonomously contribute to the emergent properties of the overall system. However, the interaction between each individual and the system is collaborative in nature. The system can only generate good recommendations if a user is willing to share social judgments via ratings of items. Without this form of interaction, a recommender system cannot adapt to the interests of a user. In contrast, users of recommender systems often do not take the system output at face value, but try to take the perceived "personality" of recommender systems into account when assessing the quality of recommendations (McNee, Riedl, & Konstan, 2006). Thus, users and recommender systems collaboratively negotiate on the topic at hand, and the ensuing mutual adaptation bears a strong similarity to CSCL processes.

Recommender systems have become quite fashionable in commercial environments, particularly with regard to items where individual preferences can differ widely, e.g. movies or music. However, in recent years the potential of personalized recommender systems for educational purposes has begun to be explored. Several systems have been designed that recommend a broad range of items, among them learning resources on the Web

(Drachsler et al., 2010; Recker, Walker, & Lawless, 2003) or entire courses (Farzan & Brusilovsky, 2006). The applications cover very different areas of learning and education like informal learning (Drachsler, Hummel, & Koper, 2009), mobile learning (Andronico, Carbonaro, Casadei, Colazzo, Molinari, & Ronchetti, 2003), or learning at the workplace (Aehnelt, Ebert, Beham, Lindstaedt, & Paschen, 2008). However, until now empirical evidence from evaluation studies using real learners is very scarce, as most educational recommender system applications have focused on prototype development or testing algorithms. In one of the few exceptions, Drachsler et al. (2010) found faster learning object completion times, a greater variety of learning paths, and higher satisfaction for learners who used an educational recommender system.

Recommender Systems: How They Can Specifically Address Learning

One of the recurring topics among designers of educational recommender systems is that one cannot simply transfer standard recommender systems to learning scenarios on a one-to-one basis; designers have to carefully address specific amendments that should be made in order to fully exploit the power of these systems in educational contexts, both for individual learning and for collaborative learning.

Support for Individual Learning

Our analysis of the design requirements for educational recommender systems is conceptualized around a network of three different factors. A first factor pertains to system characteristics: A recommender system needs data in a particular format, and it uses specific means to aggregate these data and to generate recommendations. A second factor relates to characteristics of a learner such as needs, preferences, and abilities. As a third factor educational characteristics as context come into play: Principles that are regarded as beneficial for learning. Each of the three factors as well as their combination is associated with particular tensions that impact the design of recommender systems (see Figure 1).

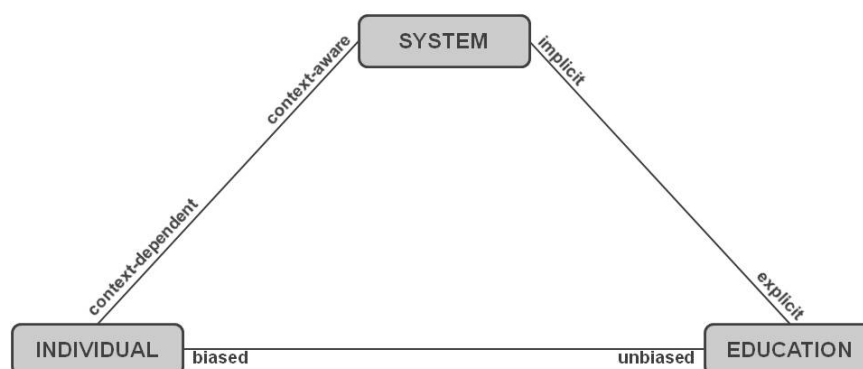


Figure 1. Tensions for the Design of Recommender Systems for Individual Learning.

Context-dependent learners vs. context-aware systems. In order to adapt to a person, a recommender system must be able to properly diagnose the person's situation. However, diagnosing learning is different from diagnosing customer behavior. For instance, when a recommender registers that a customer has viewed a recommended product and bought it afterwards, the system has been successful. In contrast, when a recommender registers that a learner has viewed a recommended item, the success of the recommendation in terms of the amount of learning cannot be measured as easily. Whether an individual has learnt something from a recommended item is highly context-dependent (Drachsler et al., 2009). A novice with a particular learning goal will benefit from a different recommendation than an expert with the same learning goal. As proficiency levels play a major role, Drachsler et al. (2009) have suggested that recommender systems for learning should not be conceptualized around isolated items like learning resources, but rather on sequences and learning paths among connected items. In order to address the context-dependency of learning, recommender system algorithms are often combined with elements from adaptive hypermedia environments like learner modeling techniques, use of metadata, and ontologies (Brusilovsky & Henze, 2007).

Implicit vs. explicit feedback. Recommender systems can rely on explicit feedback (ratings) or implicit feedback (browsing behavior, reading times). From a system perspective, several researchers have stressed the importance of implicit feedback mechanisms (e.g. Wang, 2007) because using implicit feedback is elegant, unobtrusive, and does not burden learners with the additional task of rating items. Moreover, it appears that some scholars do not trust in the accuracy of explicit ratings. For instance, one learner might assign high ratings for learning items that were regarded as very easy, whereas another learner might give high ratings for challenging items. Therefore it might be tempting to completely abandon explicit user ratings for the prediction of useful items. However, from a learning science perspective, explicit ratings have a number of advantages

over implicit methods: First, humans are often much better than machines to make judgments about fuzzy categories (Norman, 1993). Second, for learning contexts it should be noted that rating an item is a form of active participation which is regarded - at least for collaborative scenarios - as the main determinant of learning outcomes (Cohen, 1994). Third, explicit ratings require learners to reflect on an item, and reflection is an important meta-cognitive activity (Palincsar & Brown, 1984). Seen in this way, requiring learners to explicitly rate items can contribute to learning rather than diverting from a learning task. Therefore, we believe that educational recommender systems should rely on explicit ratings as much as possible. Of course, in order to get ratings that properly inform a recommender system it is clear that simple overall rating schemes do not suffice. Rather, learners should get an opportunity to rate items on different dimensions. For instance, Drachler et al. (2009) suggested including ratings on required proficiency levels (e.g. good for novices, boring for experts), ratings on the manner of presentation (e.g. clear and straightforward), or ratings of fun. More sophisticated rating schemes can provide the system with valuable data, and at the same time stimulate learners' reflection on the items they peruse.

Biased vs. unbiased processing. This tension might arise between learner and educational characteristics. Classical recommender systems suggest items based on inferred user taste. However, when it comes to learning, personal taste might not be the best driving force to improve performance (Tang & McCalla, 2004). For instance, it is well known that people have difficulties in processing information in an unbiased way. Information search often underlies a confirmation bias where preference-consistent items are favored over preference-inconsistent items (Jonas, Schulz-Hardt, Frey, & Thelen, 2001). From a learning science perspective, biased information processing is detrimental, as preference-inconsistent information is more likely to evoke beneficial socio-cognitive conflict (Doise & Mugny, 1984). Moreover, unbiased reasoning is an important element of critical and open-minded thinking (Stanovich & West, 1997). Therefore it appears useful for recommender systems to counteract confirmation bias by making salient preference-inconsistent items. Our own empirical research has investigated this issue by analyzing how learners react to preference-inconsistent recommendations (Schwind, Buder, & Hesse, this issue). It was shown that preference-inconsistent recommendations reduced confirmation bias, led to attenuation of initial preferences, and increased elaboration.

In sum, it has become evident that educational recommender systems should take particularities of individual learning into account in order to be successful. First, they need more information about learners in order to generate suitable recommendations. Second, they should make use of sophisticated external rating schemes. And finally, they should be designed in ways that counteract learners' tendencies for preference-consistent, less challenging items. If these issues are addressed, recommender systems should make for a welcome addition to our repertoire of learning technologies.

Support for Collaborative Learning

In order to explore how recommender systems must be designed to support collaborative learning, group characteristics have to be taken into account. To the best of our knowledge no recommender system for the support of collaborative learning groups has been developed yet. Nonetheless, some tentative conclusions can be drawn on how recommender systems should be accommodated in order to foster collaborative learning processes.

In the section on individual learning we outlined that recommender systems must bring three factors into line (system, individual, and educational characteristics), and that tensions among these three factors must be addressed by a recommender system. Turning to collaborative learning, group characteristics come into play as a fourth factor. As a consequence, three new tensions will arise (see Figure 2). In the following, these three tensions are discussed.

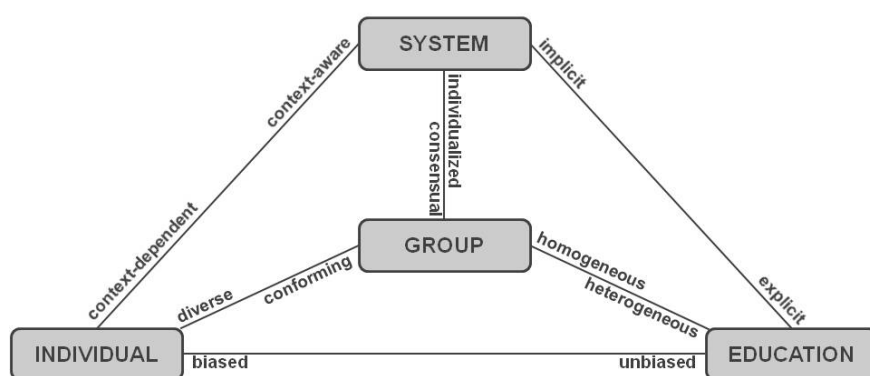


Figure 2. Tensions for the Design of Recommender Systems for Collaborative Learning.

Consensual vs. individualized ratings. In the same way that an individual expresses a social judgment through a rating, groups could be asked to discuss an item, thereby coming to a consensual rating. The system would then treat the group as some kind of “pseudo-user” (O’Connor, Cosley, Konstan, & Riedl, 2001). However, recommendations for this pseudo-user would likely to be of more benefit to some group members than to others. Alternatively, a recommender system could treat a group as a collection of individuals, capturing individual ratings, and providing individualized recommendations, and then leaving it to a collaborative group to negotiate on the output. The consensual approach is more in line with the notion of groups as backdrops for shared meaning making; the individualized approach lends more weight to potential differences among learners.

Diverse individuals vs. conforming groups. This tension relates to the differences between individuals and groups. In a social-psychological review, Hinsz, Tindale, and Vollrath (1997) concluded that for most tasks, interaction reduces initial group diversity. Of course, tasks like group decision making ultimately require some reduction of diversity, but groups have a strong tendency to rush towards conformity to an extent that is detrimental to performance. For instance, groups favor shared over unshared information even when a consideration of unshared information leads to better performance (Stasser, 1992); likewise, majority subgroup factions often prevail over minority factions even when majorities advocate an incorrect judgment (Asch, 1951).

Homogeneous groups vs. learning through heterogeneity. It was already mentioned that interacting groups have a tendency to disproportionately reduce diversity among members. They exert strong pressure to conform, leading to group homogeneity. From a learning sciences perspective, such a tendency is detrimental, as diversity and group heterogeneity are often held to be important antecedents of collaborative learning. For instance, it was shown that collaborative performance is improved if the range of achievement levels among learners is moderate rather than small or large (Webb, 1991). Another productive type of group variability is exemplified by the finding that learning and teamwork are improved if collaborators have different perspectives on an issue, as this is likely to induce socio-cognitive conflict (De Wit & Greer, 2008; Doise & Mugny, 1984).

How could a recommender system for collaborative learning accommodate for these three tensions? A potential solution is to focus on group diversity as a key variable. In order to accomplish this, ratings on items should be yielded in an individualized fashion, but then be aggregated in order to express the range of ratings rather than the average. For instance, the system should not calculate that a group found an item to be difficult on average. Instead, it could be captured that the group expressed a medium range of perceived difficulty. Items with larger variability in terms of achievement levels would then have a higher probability of being recommended. This approach would preserve diversity among group members, but still focus on those aspects that fuel successful collaborative learning.

Conclusions

This paper has investigated the question of whether and how recommender systems could be useful technologies for learning. It was argued that key features of recommender systems fit very well with current principles in the learning sciences: they are peer technologies, they augment self-regulated learning activities with scaffolds, and they offer personalized content. However, classical recommender systems are focusing on user taste, but in learning contexts, relying on user taste is neither a sufficient nor entirely appropriate way to provide good recommendations.

We conceptualized the design space for educational recommender systems around four different factors (system, individual, group, and educational characteristics) and focused on the different tensions that arise between these factors. From this discussion, some recommendations for the design of educational recommender systems can be derived: (1) recommender systems should know more than user taste when providing educationally relevant information, (2) they should focus on explicit ratings rather than implicit capturing of behavioral data, (3) they should provide information that is challenging for learners, and (4) in collaborative learning, they should be designed to preserve group variability. We believe that if recommender systems embody these principles, they can be very powerful tools to foster both individual and collaborative learning.

References

- Aehnel, M., Ebert, M., Beham, G., Lindstaedt, S., & Paschen, A. (2008). A socio-technical approach towards supporting intra-organizational collaboration. *Computer Science, 5192*, 33-38.
- Andronico, A., Carbonaro, A., Casadei, G., Colazzo, L., Molinari, A., & Ronchetti, M. (2003). Integrating a multi-agent recommendation system into a mobile learning management system. *Proceedings of Artificial Intelligence in Mobile Systems*, 12-15 October 2003, Seattle, USA.
- Asch, S. E. (1951). Effects of group pressure upon the modification and distortion of judgments. In H. Guetzkow (Ed.), *Groups, leadership, and men* (pp. 177-190). Pittsburgh: Carnegie Press.
- Brusilovsky, P., & Henze, N. (2007). Open corpus adaptive educational hypermedia. In: P. Brusilovsky, A., Kobsa, & W. Nejdl (Eds.), *The adaptive web: Methods and strategies of web personalization* (pp. 671-696). Berlin: Springer.

- Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64(1), 1-35.
- De Wit, F. R. C., & Greer, L. L. (2008). The black-box deciphered: A meta-analysis of team diversity, conflict, and team performance. *Academy of Management Best Paper Proceedings*. Anaheim, CA.
- Doise, W., & Mugny, G. (1984). *The social development of the intellect*. Oxford: Pergamon Press.
- Drachler, H., Hummel, H. G. K., & Koper, R. (2009). Identifying the goal, user model and conditions of recommender systems for formal and informal learning. *Journal of Digital Information*, 10.
- Drachler, H., Rutledge, L., van Rosmalen, P., Hummel, H., Pecceu, D., Arts, T., Hutten, E., & Koper, R. (2010). ReMashed - An usability study of a recommender system for mash-ups for learning. *International Journal on Emerging Technologies in Learning*, 5, 7-11.
- Farzan, R., & Brusilovsky, P. (2006). Social navigation support in a course recommendation system. *Computer Science*, 4018, 91-100.
- Herlocker, J., Konstan, J., Terveen, L., & Riedl, J. (2004). Evaluating collaborative filtering recommender systems. *ACM Transactions on Information Systems*, 22(1), 5-53.
- Hinsz, V. B., Tindale, R. S., & Vollrath, D. A. (1997). The emerging conceptualization of groups as information processors. *Psychological Bulletin*, 121, 43-64.
- Jonas, E., Schulz-Hardt, S., Frey, D., & Thelen, N. (2001). Confirmation bias in sequential information search after preliminary decisions: An expansion of dissonance theoretical research on selective exposure to information. *Journal of Personality and Social Psychology*, 80(4), 557-571.
- McNee, S. M., Riedl, J., & Konstan, J. A. (2006). Making recommendations better: An analytic model for human-recommender interaction. *Proceedings of CHI 2006*, Montreal, 1103-1108.
- Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine*. Boston: Addison-Wesley.
- O'Connor, M., Cosley, D., Konstan, J. A., & Riedl, J. (2001). PolyLens: A recommender system for groups of users. *Proceedings of the European Conference on Computer Supported Co-Operative Work* (pp. 199-218). Bonn, Germany.
- Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, 1(2), 117-175.
- Recker, M. M., Walker, A., & Lawless, K. (2003). What do you recommend? Implementation and analysis of collaborative information filtering of web resources for education. *Instructional Science*, 31(4-5), 299-316.
- Schwind, C., Buder, J., & Hesse, F. W. (this issue). *Fostering social navigation and elaboration of controversial topics with preference-inconsistent recommendations*.
- Sherif, M., & Hovland, C. I. (1961). *Social judgment: Assimilation and contrast effects in communication and attitude change*. New Haven: Yale University Press.
- Stanovich, K. E., & West, R. F. (1997). Reasoning independently of prior belief and individual differences in actively open-minded thinking. *Journal of Educational Psychology*, 89(2), 342-357.
- Stasser, G. (1992). Pooling of unshared information during group discussions. In S. Worchel, W. Wood, & J. A. Simpson (Eds.), *Group process and productivity* (pp. 48-67). Newbury Park: Sage
- Tang, T., & McCalla, G. (2004). Beyond learners' interest: Personalized paper recommendation based on their pedagogical features for an e-learning system. *Lecture Notes in Computer Science*, 3157, 301-310.
- Wang, P. Y. (2007). The analysis and design of educational recommender systems. In R. Carlsen et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2007* (pp. 2134-2140). Chesapeake, VA: AACE.
- Webb, N. M. (1991) Task related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education*, 22(5), 366-389.
- Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 185-208). New York: Springer-Verlag.

Support by Educators for Knowledge Building in an Organic Social Networking Environment

David James Woo, Faculty of Education, The University of Hong Kong, wootangnd@yahoo.com

Abstract: This paper analyzes educators supporting knowledge building in an organic, non-prescriptive computer-supported social network. Community activity in the social network is examined, as is the community's discourse to determine how members support knowledge building. The findings suggest that while there was prolific activity on the social network, it was confined to the early stages of the community's life, located in the discussion forum feature and largely generated by a core group of members. The discussion forum, the asynchronous communication channels and the informal nature of the community were considered affordances to knowledge building by educators on the social network. The informal nature of the community could be responsible for the community's centralization and a hindrance to supporting inactive members.

Introduction

This paper attempts to address a gap in the knowledge building literature by analyzing knowledge building (KB) by educators in an organic, informal computer-supported social network. In the present study, informal refers to the non-prescriptive, non-compulsory nature of membership and activity on the network. This study aims to address the research question, "How do educators in an organic, non-prescriptive computer-supported social network support KB?" In addition, this study is interested in obtaining insight into specific practices for the improving of computer supported collaborative learning (CSCL) design of a social networking platform for KB. An informal learning community's discourse in a social networking environment will be analyzed to determine who produced knowledge, where it was produced, when it was produced and which knowledge was advanced. The paper concludes with discussion on challenges and issues to effective KB within the context of informal professional development in a social networking environment.

Knowledge Building

KB can be seen as a social response which organizations can adopt to cope with a fundamental shift in society from knowledge learning to knowledge creation. Scardamalia (2002) has proposed 12 socio-cognitive and technological determinants of KB, and later, six themes of KB (Scardamalia & Bereiter, 2006), both of which, in sum, set apart KB from other pedagogical approaches such as constructivism, active learning and collaborative learning. Per the 12 determinants and six themes, KB can be understood as a means by which to improve knowledge collectively, moving beyond an authoritative, best practice paradigm, by advancing a diversity of *good* ideas put forth by empowered individuals who are accountable to themselves, to their communities, and to the greater society. In general, KB is not about hegemony -- who is right and who is wrong -- but about respect and equity in the generation of ideas, so as to foster a common understanding.

In the main, there is a lack of KB in schools, not least because there has not been a coherent effort to develop one in educational contexts. On the basis of those studies about KB in education which were reviewed for this current study, the extent to which KB has been developed in educational contexts can be seen. Students, young ones, high-achievers and low-achievers, have been studied to see how KB can improve their academic performance (Tse & Lee, 2006; Chan & Lee, 2007; So et al., 2010); and in a comparative cultural study, KB has been implemented in classrooms to determine its effects on Chinese students (Chan, 2010), as well as on Norwegian students (Rysjedal & Wasson, 2005). Teacher communities have been studied to understand how teachers interact in knowledge-building and non-KB tasks (Tan et al., 2008), how they work together to sustain KB (Hong, et al., 2009) and teachers' points of view on KB (Hong, et al., 2010). The development of learning communities by students and teachers' utilizing information and communication technology (ICT) have also been researched (Van Aalst & Chan, 2001; Yuen, 2003). Almost all research on KB in schools has tended to be contrived, and prescriptive, however: teachers and students involved in these studies (Van Aalst & Chan, 2001; Yuen, 2003; Rysjedal & Wasson, 2005; Tse & Lee, 2006; Chan & Lee, 2007; Tan, et al., 2008; Hong, et al. 2009; Chan, 2010; Hong, et al. 2010; So et al., 2010) were required to attempt KB as part of a formal curriculum. With respect to the type of CSCL environment employed for the KB exercise, if any, the Knowledge Forum (KF) is the preeminent CSCL platform mentioned in the literature (Van Aalst & Chan, 2001; Scardamalia, 2002; Yuen, 2003; Rysjedal & Wasson, 2005; Scardamalia & Bereiter, 2006; Tse & Lee, 2006; Chan & Lee, 2007; Tan, et al., 2008; Hong, et al., 2009; Chan, 2010; Hong, et al. 2010; So et al., 2010).

A gap in the KB literature exists at the informal level of professional development. This author has not found a study on what teachers and other school stakeholders do to build knowledge in their informal learning communities outside the confines of their formal, prescriptive duties, and opportunities, despite the likelihood

that this modality may benefit these educators by providing coaching, support and reflective practice, all of which they may lack in their institutions (So et al., 2010) and all of which are vital to establishing a collaborative culture through which KB can thrive (Chan & Lee, 2007). These informal educator communities can serve an important role in delivering KB skills to educators through self-practice because, “One way to help teachers to develop a deeper conceptual understanding of teaching as a process of knowledge-building may be to engage them in the actual ‘knowledge-building’ practice” (Hargreaves, 1999; Hong & Sullivan, 2009; as cited in Hong, et al., 2010, pp.1). Their potential to transform continuous professional development through KB requires greater attention in the literature.

Another gap in the literature is found at the choice of CSCL environment used for KB studies. The preponderance of KB studies which utilize the KF (Van Aalst & Chan, 2001; Scardamalia, 2002; Yuen, 2003; Scardamalia & Bereiter, 2006; Chan & Lee, 2007; Tan, et al., 2008; Hong, et al., 2009; Chan, 2010; Hong, et al. 2010; So et al., 2010) may suggest that, in addition to KF being an effective CSCL vessel in which to contain KB, the KF may be the only CSCL environment in which KB can be performed. Despite some literature on wikis (Harrer et al., 2008; Moskaliuk et al., 2008) as a viable KB support, the prevailing narrow scope of CSCL environments in KB limits understanding of how technological constraints endemic to KF affect KB and more generally, how different CSCL environments provide affordances and hindrances to more effective KB.

The Informal Educator Community

The community in the present study comprises 123 members representing 29 organizations from four countries, 26 of those organizations being schools. 23 subject areas were represented. Approximately 45% (n=55) of the community members identified themselves as primarily teachers, 24% (n=29) department heads or coordinators, 15% (n=18) administrators, 11% (n=13) support staff (e.g. librarians; programmers; technicians; therapists; advisers; consultants; and facilitators), and 7% (n=8) other (e.g. unidentified; students; and professors).

The community is founded on a common goal of preparing for a technological and pedagogical innovation. Community membership is voluntary, as is participation in the community. In addition, a high level of *epistemic agency* is given to community members. Each member can freely produce content such that the member exerts significant control over the components of the community’s KB effort.

Knowledge Building in the Organic Social Networking Environment

This section describes how educators supported KB on the social network. It reports where knowledge was produced, when it was produced, who produced it, and which knowledge was advanced by analyzing social network activity between users, and between features and within features, and by examining the discourse produced by the activity.

Instances of new activity were calculated for the five main features of the social network (i.e. discussion; groups; events; videos and photos) and several patterns emerged from the data. In the main, text-based modalities were used most frequently by community members: the discussion forum had the most instances of activity (n=204), and while the photos feature was the recipient of the second-most number of instances of activity (n=53), that content was produced by only one community member on a single day. There was a significant difference in the number of activity instances between the most frequently used feature and the second-most frequently used feature (n=151), indicating that, by far, members preferred to communicate on the community discussion forum.

Another pattern to emerge from analyzing the social network activity by feature was the diminishing instances of activity by time. Overall, the activity level in the social network was the highest in the first few months of the community, and then began dropping sharply. Following the initial flurry of activity on the social network, there were relatively few spikes in activity for any feature.

The community’s discussion forum was investigated in-depth because it was the focal point for members’ participation. 38 threads were counted, with an average of 5 replies (n=4.66) per thread. The median number of replies per thread was 2, and the mode number of replies per thread was 0. 34% of threads (n=13) had received at least 5 replies. The average number of words per post was 117 (n=116.97).

The average number of unique posters per thread was approximately 3. 18% of threads (n=7) had at least 5 unique posters. 29% of community members (n=36) contributed at least one post to the discussion forum. When participation is presented by members’ roles, 25% of teachers (n=14), 34% of department heads and coordinators (n=10), 39% of administrators (n=7), 31% of support staff (n=4) and 13% of other members (n=1) contributed.

yEd software was used to visualize discussion forum user activity (see Figure 1) in terms of user centrality. The most connected member of the network serving as the baseline (that is, the member who has been in contact with the most other members of the network by participating in the discussion forum), only one member achieved at least 50% of that baseline member’s centrality, with 49% of active members (n=17) achieving at least 25% of that baseline member’s centrality. Of all the central members, 50% (n=9) identified themselves primarily as teachers, 33% (n=6) as heads or coordinators, and 17% (n=3) as support staff.

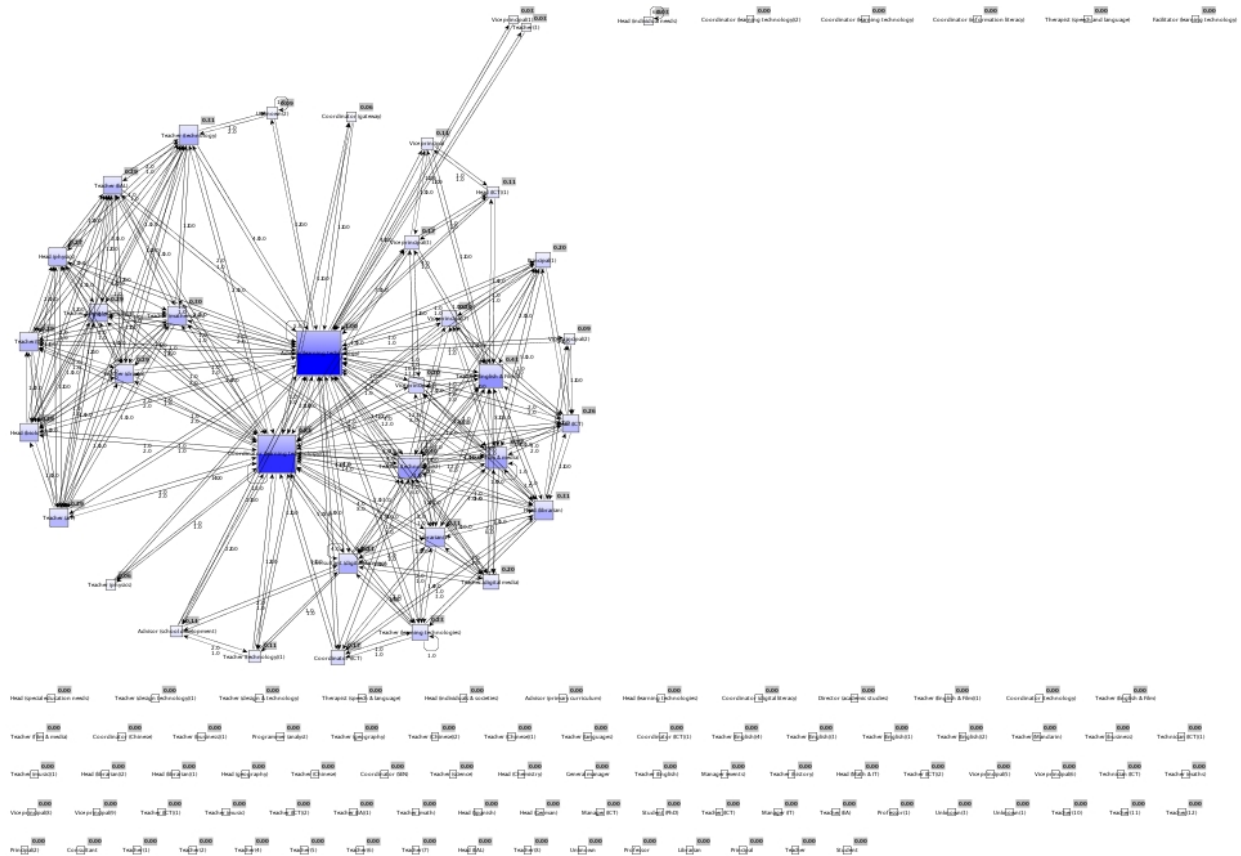


Figure 1. Visualization of Member Activity with Member Centrality Measures.

Table 1: Coding of posts according to knowledge building themes.

Discussion Topic (n=total number of posts) / Knowledge Building Themes	1 (n=31)	2 (n=8)	3 (n=6)	4 (n=8)	5 (n=14)	6 (n=7)	7 (n=20)	8 (n=17)	Total Instances of Theme
Knowledge advancement as a community rather than individual achievement	15	6	3	3	11	5	13	15	71
Knowledge advancement as idea improvement rather than progress toward true or warranted belief	13	7	3	2	11	5	13	14	68
Knowledge of in contrast to knowledge about	17	4	3	4	7	4	11	11	61
Discourse as collaborative problem solving rather than as argumentation	15	6	2	3	6	6	14	12	64
Constructive use of authoritative information	16	4	2	3	8	3	10	5	51
Understanding as emergent	17	7	3	2	11	6	16	13	75

The discussions which demonstrated longevity and prolificacy (n=8) were further analyzed for KB to shed light on the quality of the knowledge being built in the social network. Each post was coded according to the six KB themes that were enumerated by Scardamalia and Bereiter (2006) and that signify membership in a KB community. (See Table 1.) A post could be coded under more than one theme, or it could be unclassified according to the Scardamalia framework since the post was not an occurrence of KB.

Several observations about KB could be made about the eight discussions. In the main, there was substantial KB for each topic as posts within those topics could be subsumed under the KB themes. Posters were less concerned about authority and individual accuracy and more concerned about furthering cooperation between members. For example, a lengthy discussion on Internet safety resulted in such a contribution as:

Looks like we all seem to be moving in a similar sort of direction with this. I've said before on another forum that we are really addressing issues of digital citizenship and is the phrase that I think best describes this whole area of interaction. You rightly address the point that...I'd really be happy to work with you on this to be honest so that we can develop some materials together...Maybe we could do some inter school activity?

Discussion

This paper examined how educators support KB on a social network within the context of an informal professional development community. It determined that while there was significant activity on the network, it was confined to the early stages of the community's life, located in the discussion forum feature and largely generated by a core group of members assuming a wide range of roles in their schools. Nonetheless, KB was observed within the discourse. In sum, there was uneven support for KB in terms of member participation per feature and over time.

The findings help to explain the affordances of KB on this type of social network. That the discussion forum was the primary medium for KB supports Van Aalast and Chan's (2001) finding that online discussion was a catalyst for community building and may contradict Scardamalia and Bereiter's (2006) assertion that discussion boards overall were not as conducive towards KB as the KF was. In this case, the community members preferred the discussion board feature to the videos, photos, groups and events features on the social network in creating and sustaining KB activity. It may be crucial to provide text-based modalities for KB in computer-supported collaborative learning environments. More research is needed into the effects of ICT multiple modalities on KB.

That several discussions received posts over the course of years suggests that there is a particular KB affordance of a semi-permanent, asynchronous communication channel used in conjunction with the informal nature of the educator community. In essence, the KB task does not have to *end*. In fact, it appears that providing semi-permanent storage of information along with relatively free exit and entry into the community can perpetuate KB on a social network so long as members desire to cooperate in advancing knowledge. Therefore, given that the discourse in a thread can last years, an important consideration is to notify all members when new information is added to the network. Furthermore, the context of this study supports Scardamalia and Bereiter's (2006) argument that prescriptive rules and procedures may facilitate KB but they do not necessarily foster quality, whereas a more general set of principles allows flexibility in knowledge development and seems to improve knowledge quality. The discourse on the social network lacked explicit rules yet there was vibrancy in several of the discussions.

The informal nature of the community and the social network features created a centralized community. Although many people joined the community, only several of them contributed actively, if at all, to KB tasks. Per Van Aalast and Chan's (2001) finding, there was not a single community in the sense that all members on the social network contributed to the KB; many on the social network signed up and never generated any content on their own; but those that did tended to do so prolifically and enthusiastically, resembling in their coherent roles what Scardamalia (2002) deemed an *expert team* of competent workers who assume a wide range of roles in their schools and who not only know their individual roles well but also know those of their peers insofar as by their cooperation, the team can overcome myriad challenges and complications. Within an informal community on a social network, a product of successful KB could be the emergence of an expert team. Likewise, without the contributions of these core, centralized members, the social network would be in want of activity.

That the majority of community members did not contribute warrants further exploration. Van Aalast and Chan (2001), Scardamalia (2002) and Hong (2010) have put forth findings on cognitive barriers to successful KB, which include differing, if not obstructive expectations and understandings of KB discourse amongst members. The informality of the community may not have been conducive towards providing measured and appropriate assistance to members who wanted to contribute significantly to the discourse but did not know how. In the main, more investigation is needed to determine whether those explanations fit the circumstances of those educators in this study that did not contribute at all to the activity on the social network.

References

- Chan, C. K. K., & Lee, E. Y. C. (2007). *Fostering knowledge building using concurrent, embedded and transformative assessment for high-and low-achieving students*. Paper presented at the Proceedings of the 8th international conference on Computer supported collaborative learning, New Brunswick, New Jersey, USA.
- Chan, C. K. K. (2010). Classroom Innovation for the Chinese Learner: Transcending Dichotomies and Transforming Pedagogy. In C. K. K. Chan & N. Rao (Eds.), *Revisiting The Chinese Learner* (Vol. 25, pp. 169-210): Springer Netherlands.
- Harrer, A., Moskaliuk, J., Kimmerle, J., & Cress, U. (2008). *Visualizing wiki-supported knowledge building: co-evolution of individual and collective knowledge*. Paper presented at the Proceedings of the 4th International Symposium on Wikis, Porto, Portugal.
- Hong, H.-Y., Zhang, J., Teo, C., & Scardamalia, M. (2009). *Towards design-based knowledge-building practices in teaching*. Paper presented at the Proceedings of the 9th international conference on Computer supported collaborative learning - Volume 1, Rhodes, Greece.

- Hong, H.-Y., Chen, F.-C., Chai, C. S., & Chan, W.-C. (2010). *Teacher-education students' views about knowledge building theory and practice*. Paper presented at the Proceedings of the 9th International Conference of the Learning Sciences - Volume 1, Chicago, Illinois.
- Moskaliuk, J., Kimmerle, J., & Cress, U. (2008). *Learning and knowledge building with wikis: the impact of incongruity between people's knowledge and a wiki's information*. Paper presented at the Proceedings of the 8th international conference on International conference for the learning sciences - Volume 2, Utrecht, The Netherlands.
- Rysjedal, K., & Wasson, B. (2005). *Local and distributed interaction in a collaborative knowledge building scenario*. Paper presented at the Proceedings of th 2005 conference on Computer support for collaborative learning: learning 2005: the next 10 years!, Taipei, Taiwan.
- Scardamalia, M. (2002). Collective Cognitive Responsibility for the Advancement of Knowledge. In B. Smith & C. Bereiter (Eds.), *Liberal education in a knowledge society*. Chicago, Ill.: Open Court.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge Building: Theory, Pedagogy, and Technology. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97-118). Cambridge ; New York: Cambridge University Press.
- So, H.-J., Seah, L. H., & Toh-Heng, H. L. (2010). Designing collaborative knowledge building environments accessible to all learners: Impacts and design challenges. *Comput. Educ.*, 54(2), 479-490. doi: <http://dx.doi.org/10.1016/j.compedu.2009.08.031>
- Tan, J., Chai, C. S., & Hong, H.-Y. (2008). *The Analysis of Small Group Knowledge Building Effort among Teachers Using an Interaction Analysis Model*. Paper presented at the 16th International Conference on Computers in Education, National Central University, Taipei, Taiwan.
- Tse, W. C. A., Lee, F. L., & Ou, Y. (2006). *The Effectiveness of Knowledge Building through Computer Supported Collaborative Learning among Elementary Students: A Case Study*. Paper presented at the Proceeding of the 2006 conference on Learning by Effective Utilization of Technologies: Facilitating Intercultural Understanding.
- Van Aalst, J., & Chan, C.K.K. (2001, March). *Beyond "sitting next to each other": A design experiment on knowledge building in teacher education*. In P. Dillenbourg, A. Eurelings, and K. Hakkarainen (Eds.), *European perspectives on computer-supported collaborative learning: Proceedings of the first European conference on computer-supported collaborative learning* (pp. 20-28). Maastricht: University of Maastricht.
- Yuen, A. (2003). Fostering Learning Communities in Classrooms: A Case Study of Hong Kong Schools. *Educational Media International*, 40(1), 153 - 162.

Group Meaning in Mathematical Discourse: A Multimodal Analysis of PreK Students Using Multi-Touch Virtual Manipulatives

Michael A. Evans, Department of Learning Sciences and Technologies, Virginia Tech, Blacksburg, VA, 24061 USA, mae@vt.edu

Jesse L.M. (Jay) Wilkins, Andrea Motto, Department of Teaching and Learning, Virginia Tech, Blacksburg, VA, 24061 USA,

Email: wilkins@vt.edu, andreamotto@vt.edu

Adrienne Brunger, Department of Mathematics, Virginia Tech, Blacksburg, VA, 24061 USA, abrunger@vt.edu

Jeremy Crider, Department of Computer Science, Virginia Tech, Blacksburg, VA, 24061 USA, crider12@vt.edu

Abstract: For the current study, we applied a multimodal technique to examine discourse among PreK students (ages 4-5) as they used virtual manipulatives (tangrams) on a multi-touch surface under varying conditions of interdependence. Selecting heightened episodes of talk, gesture, and gaze in videotaped sessions, we identified coreferential chains that demonstrate how geometric puzzle solving can serve as examples of group cognition. Initial findings indicate distinct points of cohesion around topics and the possibility of differentiating mathematical talk (denoted by domain-specific concepts, relationships, and transformations) from project talk (denoted by problem solving and socio-cognitive aspects of discourse).

Overview

Our research is motivated by the construct of group cognition as a metaphor to investigate computer supported collaborative learning (CSCL), advances in early childhood mathematics education, and the design, use, and evaluation of virtual manipulatives for multi-touch/-user surface computing technologies. For the current paper, we focus on the development and use of virtual manipulatives for a multi-touch/-user system, the SmartTech SMART Table™. The table is specifically designed for PreK-5 learners and provides an attractive platform for our research and development activities. Consequently, in the following sections we discuss how priorities on group cognition have guided the design and development of our applications. We position our work in terms of recent calls for research and development in direct manipulation of digital interfaces for teaching and learning.

Virtual Manipulatives on Multi-Touch Tabletops: Advanced CSCL Technologies

As pointed out by Tapper (2007), “manipulatives, like tangrams, help students build on prior knowledge and expand both their math content knowledge and their problem solving skills” (p. 11). Combined with multi-touch, multi-user interactive tabletops such as the SmartTech SMART Table™, the design, implementation, and use of virtual manipulatives opens the platform to possibilities worthy of research and development in CSCL. Multi-touch/-user tabletops and surfaces have become an area of interest for learning scientists, mathematics education researchers, and software developers. As research is beginning to reveal, students may focus more on the task at hand working in a more collaborative environment by freely using their hands and fingers to manipulate objects on interactive surfaces. Interactive whiteboards (IWB), a good case for multi-touch applications, have greatly improved presentation, motivated students, and enhanced learning with inbuilt programmed links and applications (Glover, Miller, Averis & Door, 2005; Romeo, Edwards, McNamara, Walker, & Ziguras, 2003). Thus, our work attempts to analyze and support group cognition in small-group settings where students informally explore ideas in mathematics. The combination of a theoretical ground (group cognition), pedagogical guide (informal geometry), and advanced technologies (multi-touch/-user surfaces) allows for a rich area of research and development.

Methods

Our methods aim to identify the communicative strategies of Pre-K children when faced with the task of solving geometric puzzles in small-group settings and the potential for exhibiting group cognition in mathematics learning contexts. By examining children’s speech, gesture, gaze and actions, we investigated the points of discursive cohesion that structure children’s collaborative reasoning throughout the problem solving process. Cohesive points were identified via “coreferences” after McNeill (2009). In its most basic sense, a coreference can be understood as the repeated expression of a single referent delineated in our work as follows:

- **Object-level coreferences** are references to an object or place in the physical world (e.g., “This triangle,” “Here,” or “Look at this.”).
- **Meta-level coreferences** are references to the discourse itself or to the problem solving process, including specific references to the computer program, and time limits (e.g., “That wouldn’t work,” [where that

represents a previous utterance] or “It goes there,” or “We need to start over,” or “No this way,” or “It’s my turn.”).

- **Para-level coreferences** are references to the participants themselves, the group, or emphasize a speaker’s viewpoint (e.g., “Now you go,” or “I know,” or “I got you.”).

For the current study, we conducted a series of trials with 4- and 5-year old students at a university-based early childhood education center. In these trials, students were instructed to solve geometric puzzles using the SMART Table™ in a non-classroom, controlled setting. For the reported analyses, a group of three boys and a group of two girls each completed a series of five tangram puzzles. To encourage communication and negotiation of ideas, three different constraints were used. For the first puzzle, *free ownership* was offered, allowing all students to touch any of the puzzle pieces. For the second puzzle, *divided ownership* was offered; each student was restricted to manipulating only the pieces that matched his or her assigned color. For the final three puzzles, *single ownership* was offered; one student had permission to touch the pieces, while the others could only offer suggestions.

Refining Categories of Meta-level Coreferences

In this study, we were able to identify an additional layer of analysis not used in previous work (Evans et al., 2011). In particular, for certain meta-coreferences, there may be a rule or principle that provides the context for the coreference instead of using a previous utterance within the current discourse episode as a meta-coreferent. For example, the rules included in the instructions given to the children before the start of the task. Indeed, so far we have found that many utterances and gestures contain implicit references to geometric principles (e.g., fitting larger pieces in first, staying within the lines, particular properties of the pieces) as well as implicit references to principles governing collaborative problem-solving (e.g., turn-taking or working together). Therefore, in coding, we distinguished between two types of meta-level coreferences: *mathematical* versus *project*. Differentiating between these two types of metacognition is useful in understanding the development of collaborative and problem-solving skills.

- **Mathematical coreferences** allude to geometric/mathematical principles and the properties of puzzle pieces. (e.g., “That fits.” or “It keeps leaving that white space.”);
- **Project coreferences** adhere to collaborative problem-solving strategies or cooperation. (e.g., “Let’s start over.” or “My turn goes next.”).

Our point is that mathematical and project coreferences are key to the organization of group cognition but function in different ways within the discourse. Mathematical-type meta-coreferences may be part of building skills in mathematical and geometric reasoning, as well as demonstrating an understanding of the geometric parameters of the task. Project-type meta-coreferences cohere to the group dynamics and the implicit social rules of cooperation, collaboration, and step-by-step group problem solving. Thus, pivotal moments of collaboration are identified as patterns in the structure of coreferences that drive the problem-solving forward.

Results

Video transcripts were independently coded by two research assistants for meta-, para-, and object-level coreferences. These coreferential chains are offered as incidents of group cognition. The following excerpt provides an example of a heightened episode in which two 5-year old girls, Emily and Gwen, work together on a puzzle constrained by a divided ownership puzzle condition. Recall that in divided ownership each student is assigned a color (red, green, or blue) and may only touch pieces of that color. They may, however, verbally negotiate placement of all of the pieces with the other member of the group. In the excerpts used below to illustrate our technique, as the children near the completion of the puzzle, they work together to negotiate the placement of the final piece. Both verbal and non-verbal coreferences were coded in accordance with the transcripts (see Table 1). Through multimodal analysis, we were able to identify the focused attention on the movement and position of the red triangle within the puzzle as a coalition between students. In Figure 1a, b, and c, we demonstrate three moments of cohesion within approximately 10 seconds of the puzzle in which the students exhibit features of group cognition.

Table 1: Transcription of girls’ puzzle with coreferences.

Time	Name	Talk	Gesture	Coreferences	Project/ Math Coreferences
0:00- 0:01	Gwen	I have one more piece.	Gwen holds right forefinger on the blue square. Emily adjusts the red parallelogram.	Para (V) Obj (V/NV) Meta (V)	Project (V)

0:02-0:04	Ms. Lisa	Good job.	Gwen slides the blue square across the table and onto the puzzle	Obj (NV)	
0:04-0:05	Emily	Heh-heh.	Gwen rotates the blue square into place.	Obj (NV)	
0:06-0:07	Gwen	There. Now yours.	Gwen leans back, pointing briefly to the red triangle as she moves.	Obj (V/NV) Para (V) Meta(V)	Project (V)
0:08-0:10	Emily	Mine needs to be flipped.	Emily places both forefingers on the red triangle and rotates it 180 degrees.	Obj (V/NV) Para(V) Meta (V)	Math (V) Project (V)
0:11-0:13			Using 2 forefingers, Emily slides the red triangle to the white space at the top of the puzzle.	Obj (NV)	
0:14-0:16	Gwen	((giggles)) No not flip	Emily smiles; then rotates the red triangle 180 degrees.	Meta (V) Obj (NV)	Math (V) Project (V)
			Emily slides red triangle into place	Obj (NV)	

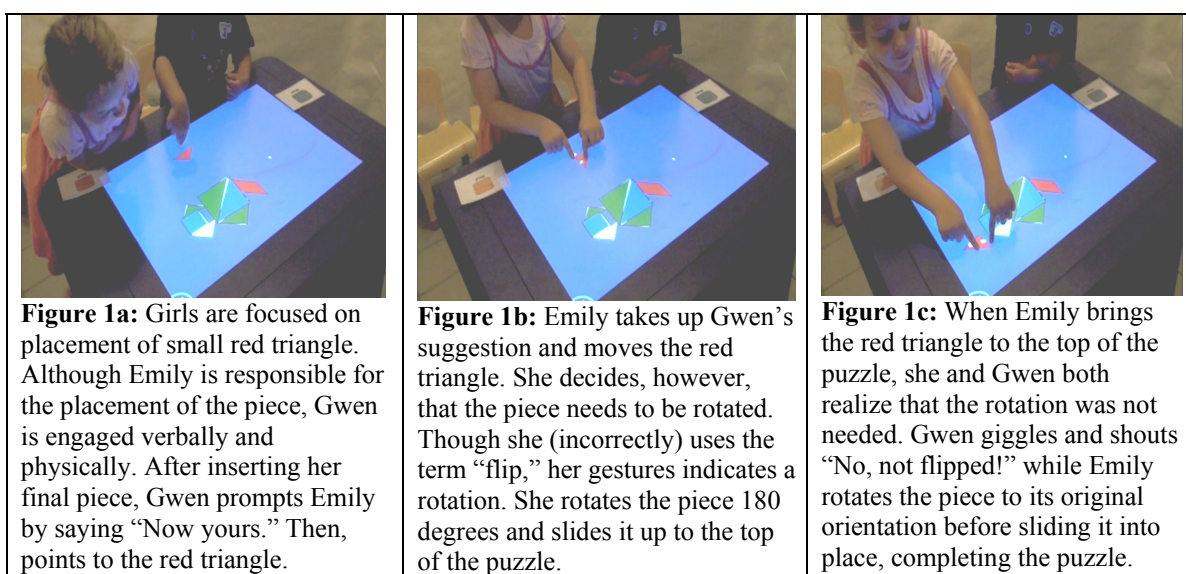


Figure 1. Screenshots and Descriptions of Girls' Puzzle.

The next excerpt demonstrates a heightened episode in which three 5-year old boys, Charlie, Jason, and Rico work together on a puzzle also constrained by divided ownership. The boys' attention is focused on the placement of a large blue triangle into the white space in the puzzle. Charlie is the only child permitted to touch the piece. Both verbal and non-verbal coreferences were coded in accordance with the transcripts (see Table 2). In the figure below (Figure 2), the three boys, Rico, Charlie and Jason have focused their attention on the movement and placement of the large blue triangle. As we can see from the screenshots, Jason's attention is drawn toward Charlie, who is rotating the triangle near the edge of the screen. After Charlie comments on the rotation of the piece, Jason suggests a location using both physical and verbal forms of communication.

Table 2: Transcription of boys’ puzzle with coreferences.

Time	Name	Talk	Gestures	Coreferences	Math/ Project Coreferences
0:21 - 0:22	Charlie	I know we turn it this way.	Charlie uses his middle 3 fingers to adjust the large triangle.	Obj (V/NV) Para (V) Meta (V)	Math (V)
			Charlie slides triangle toward puzzle using index finger and thumb.		
0:23 - 0:24	Jason	Have to go. . . have to go here.	Jason points at the empty white section of the puzzle.	Meta (V) Obj (V/NV)	Project (V)

	Charlie	[Hey!]	Charlie stops moving the triangle but keeps his index finger touching		
0:24 - 0:26	Charlie	Oh, it goes there, Jason.	Jason taps the spot for the triangle twice with index finger then moves hand away slowly.	Obj (V/NV) Meta (NV)	Project (V)
			Charlie moves the triangle toward where Jason is pointing.		
0:27 - 0:30	Ms. Lisa	Yeah, oh good job, Charlie. Fantastic	Rico stops adjusting top triangle, pulls back from the table.	Obj (NV)	
			Charlie finishes placing triangle.		
0:31 - 0:31	Rico	How 'bout mines.		Para (V) Obj (V)	

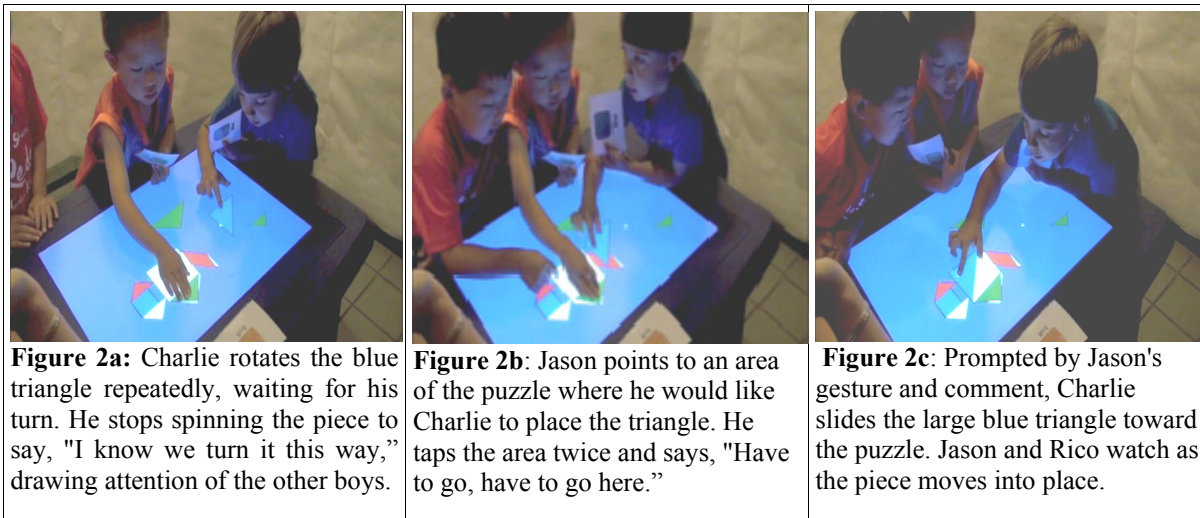


Figure 2a: Charlie rotates the blue triangle repeatedly, waiting for his turn. He stops spinning the piece to say, "I know we turn it this way," drawing attention of the other boys.

Figure 2b: Jason points to an area of the puzzle where he would like Charlie to place the triangle. He taps the area twice and says, "Have to go, have to go here."

Figure 2c: Prompted by Jason's gesture and comment, Charlie slides the large blue triangle toward the puzzle. Jason and Rico watch as the piece moves into place.

Figure 2. Screenshots and Descriptions of Boys' Puzzle.

While Rico does not suggest a placement for the piece, his engagement is confirmed by his concern for the placement of his own piece ("How 'bout mines.>"). We found that talk alone was not a comprehensive indicator of group cognition. For example, in the two excerpts above, we found 17 coreferences in the video clip of the girls puzzle and 11 coreferences in the boys' clip. However, 8 of the girls' coreferences and 5 of the boys' coreferences were non-verbal. Looking at gestures in addition to talk nearly doubled the number of coreferences found in both girls' and boys' video clips. In expanding our data set, multimodal analysis grants us the types and amounts of data required to discuss group cognition with greater confidence and detail (Strijbos & Stahl, 2007).

Discussion

Multi-modal Analytical Techniques and Group Cognition

Multi-modal techniques that examine talk, gesture, gaze, and activity are not unknown to the CSCL research literature. Works by Cakir, Zemel, and Stahl (2010) and Strijbos and Stahl (2007) have demonstrated the benefits of using multimodal techniques to examine collaborative learning. Though Cakir et al. (2010) were investigating the use of a digital whiteboard in a virtual mathematics chat room setting, results from this work corroborate our emphasis on focusing on coreferential or joint problem solving moments in the discourse to find traces or evidence of group cognition. Moreover, the techniques adopted by Cakir et al. (2010) justify our adoption of microgenetic ethnographic methods to identify discrete moments of group cognition. Where our work is distinguished from theirs is the emphasis of co-located interaction and collaboration. The virtual chat room space decreases, or entirely removes, indications rendered by gesture. Though our work aligns in emphasizing gaze and how it might establish a dual space, we extend these efforts by including the gestural component that has been found critical in conveying mathematical ideas (McNeill, 2009).

Mathematical Talk versus Project Talk: Group Cognition and Discourse

As indicated, our analyses of the preschool children working with virtual manipulatives on the multi-touch/multi-user tabletop has allowed us to further refine the category of meta-level coreferences. We are now

able to distinguish between what we have categorized as *mathematical* talk and *project* talk, providing further insights into how children deal with multiple layers of multimodal discourse as they engage in problem solving activities in mathematics. Sfard (2008) has proposed the concept of *commognition* (merging the ideas of communication and cognition) to describe the multi-levelness of mathematical thinking and reasoning. Her point is that to understand the development of higher order thinking processes in a developmental fashion, particularly when investigating the emergent levels of thinking in young children, it is important that mathematical thinking be conceptualized as multi-level and multi-referential. In our data sets from girls and boys, we are able to detect the levels of communication (or discourse) taking place among the children as they refer, and co-refer, to persons, objects, and activities. Our analyses point to evidence of commognition among the students as indicated in mathematical and project talk. Where differences lie, as we have detailed in our excerpts, is how levels are differently emphasized among peers and how boys and girls differently appropriate these levels to achieve or exhibit a distributed cognition of problem identification and, eventually, solution. Whereas group cognition serves well as a general framework for our analytical techniques, commognition provides additional reference as we explore the distinctions between mathematical and project talk.

Conclusions and Implications

A multimodal approach to analyzing mathematical discourse allows us to "see" potentially what is conceptualized as group cognition. By combining gestural analysis with conventional discourse analysis, we are able to recognize an elaborate system of verbal and non-verbal communication used by Pre-K students to engage in collaborative problem-solving in a virtual environment. In the two examples detailed in this paper, much of the talk and many of the gestures are directed toward another child who is also engaged in completing the puzzle, leading us to the conclusion that mathematical learning is not merely an individual pursuit, but also social endeavor. The results from the currently reported work include the following: 1) earlier work on the relative affordances of physical and virtual manipulatives has the *virtualization* of social cues and artifacts to promote collaborative, co-constructive reasoning; 2) out-of-the box applications and the teacher toolkit included with the SMART Table™ insufficiently support collaboration and co-construction; and 3) the ecology of design of virtual manipulatives demands the meditational role of the teacher for more productive efforts that better serve the classroom. Furthermore, the ideas gleaned from this method of analysis are being embedded into the design of further SMART Table applications for the classroom. These data, along with feedback from facilitators and teachers, provided essential information regarding usability of the application, which were then instrumental in the redesign of the tangram puzzles. We feel the method described is a promising one to detect group cognition. Our goal is to contribute empirical evidence to this mission at the micro level.

References

- Cakir, M.P., Zemel, A., & Stahl, G. (2010). The joint organization of interaction within a multimodal CSCL medium. *International Journal of Computer-Supported Collaborative Learning*, 4(2), 115-149.
- Evans, M.A., Feenstra, E., Ryon, E., & McNeill, D. (2011). A multimodal approach to coding discourse: Collaboration, distributed cognition, and geometric reasoning. To appear in the *International Journal of Computer Supported Collaborative Learning*.
- Glover, D., Miller, D., Averis, D., & Door, V. (2005). The interactive whiteboard: A literature survey. *Technology, Pedagogy and Education*, 14(2), 155-170.
- McNeill, D. (2009). Gesture as a window onto mind and brain, and the relationship to linguistic relativity and ontogenesis. In C. Müller, E. Fricke, et al. (Eds.), *Handbook on Body, Language, and Communication*. New York: Mouton de Gruyter.
- Romeo, G., Edwards, S., McNamara, S., Walker, I. & Zигuras, C. (2003). Touching the screen: issues related to the use of touchscreen technology in early childhood education. *British Journal of Educational Technology*, 34(3), 329-339.
- Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourses, and mathematizing*. New York: Cambridge University Press.
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
- Strijbos, J. W., & Stahl, G. (2007). Methodological issues in developing a multi-dimensional coding procedure for small group chat communication. *Learning & Instruction. Special issue on measurement challenges in collaborative learning research*, 17(4), 394-404.
- Tapper, J. (2007). Tangrams and geometry concepts. *Connect Magazine*, 20(4), 7-11.

Acknowledgments

National Science Foundation (Awards 0736151, 0832479); SMART™ Technologies

Privacy, Trust and the Practice of Learning Management Systems

Kai-Uwe Loser, Thomas Herrmann, Ruhr-University Bochum, Germany,
Email: kai-uwe.loser@rub.de, thomas.herrmann@rub.de

Abstract: Current LMS like Blackboard or Moodle have a great potential to be improved with respect to privacy and data protection. Legal compliance is only one reason for this need. Another is that trust and privacy are linked and an open culture for learning with respect for each other needs contributions from respecting privacy. The paper argues from theoretical directions of privacy and data protection guidelines and from power relations with a empirical background from practical usage at a university in Germany.

Introduction

“Trust between teachers and students is the affective glue that binds educational relationships together. Not trusting teachers has several consequences for students. They are unwilling to submit themselves to the perilous uncertainties of new learning. They avoid risk. They keep their most deeply felt concerns private. They view with cynical reserve the exhortations and instructions of teachers.” (Brookfield 1990, p. 162)

“Who is not sure, that deviant behavior could be noted anytime and written down, used as information and transferred, will try to avoid to show any of this kind of behavior.” (German Constitutional Court 1984 – authors’ translation)

The first cite from Brookfield covers the topic of trust within the personal relations between teachers and learners. The latter cite comes from the historic court decision of the German Constitutional Court arguing for privacy from a constitutions perspective. It is obvious from both citations that privacy is a facet to preserve freedom, and as well it is widely acknowledged that preserving privacy is one of the components of creating trust between learners and teachers. Protecting privacy on the technology part should therefore contribute to a positive attitude in the relation between the various actors. We currently see complex systems – Learning Management Systems (LMS) like moodle or blackboard – which actually store a huge amount of data. The primary focus of course cannot be privacy and data protection, but analysing LMS we found that currently in many cases too many data about students’ behavior is processed. At some institutions we see an open discussion about whether the systems are trustable. It happens especially in a field where system application is connected with civic education that needs to be aware of rights and responsibilities. Here we can see the direct link between the two citations from the beginning of this paper. The link between trust and the learning culture is known as well as the results of ubiquitous observation, in other words limited privacy. In consequence it is a little surprise that in many LMS well known privacy and data protection principles were widely ignored.

Discussing privacy and data protection the first perspective that comes to mind is IT security. The LMS are nowadays used in large environments and therefore security aspects – especially the technical perspective – already received some attention (e.g. Eckert 2003, Eibl 2009). The organizational perspective is often argued from a policy level (Culnan & Carlin 2009) but it is also known that policies are limited. On the one hand practice is that in many countries codes of conduct are the main approach to accomplish privacy and data protection. On the other hand whether or not technical features ensure confidentiality and security largely depends on the actual behavior of users involved (Lampson 2009). In this paper our perspective is a ‘privacy-by-design’ approach which emphasizes neither a security perspective nor a pure organizational approach.

Our work was based first on an analysis of the main platform of one university with about 30.000 students. The challenges described in this paper were also backed up by a literature analysis with descriptions of systems practically used in universities. These were confirmed and clarified by discussing the issues with privacy commissioners of other universities in Germany. The overall process made several deficits visible, and on this foundation there were three interviews conducted, where it was tried to clarify the actual needs of lecturers. The following section will present some backgrounds on privacy aspects. The following section we will argue for some concrete ways to support trust by privacy and data protection measures from our empirical background and the requirements of data protection.

Background to Privacy and Data Protection

Acknowledging Power Relations

From CSCW-oriented privacy discussions (Clement 1992, Bellotti and Sellen 1993) we know that for effective cooperation personal knowledge about others is necessary (Awareness). At the same time this is intrusive to

privacy. Solutions there are based on the assumption that cooperating users have a symmetrical peer-to-peer type of relationship. None of the users has the right or power to enforce another to a certain behavior. In teaching contexts we usually find this kind of symmetric role relations when students cooperate. In E-Learning we also see asymmetric constellations, where one group can sanction another: student vs. teacher, students vs. administration. Within asymmetric relationships privacy and data protection problems usually create more harm to the individuals. Privacy and data protection principles as they are defined in the legislation are intended especially for this kind of constellations.

The success of LMS usage depends to some level on the motivation, which is also related to trust between all parties involved. The amplification of already asymmetric power relations by unbalanced functionality to control others is counterproductive. We see wide discussions of phenomena in some universities focused on this kind of topics. What is a necessary and appropriate level of control that tutors can perform? We argue for rethinking the systems reflecting these differences in relationships: access and visibility of presence information might be acceptable when students cooperate, on the other hand vision of tutors is limited to appropriate details. They especially see aggregations of data, useful to their needs. Another aspect is that sometimes actions of tutors are hidden in the system. You cannot see which documents tutors visited. Behaving transparently (within systems supporting this) is a possible strategy to create trust. Hiding behavior, and leaving intentions to the imagination of controlled parties leads to the opposite and can harm learners' motivation. Some evidence for this can be found by searching other discussion forums and social communities for discussions about subjects of courses. "Only the smart questions are asked there anyway. The stupid questions are discussed elsewhere." – a cite of a student. It should make clear that anonymity of questions – although it also may have other problems – is necessary, to get the stupid questions as helpful feedback. For our empirical background the used platforms for the discussions can be named for several faculties. Discussion of taught content is needed, but obviously this is not happening in LMS as intended, but elsewhere. Power relations seem to add on this. Beyond legislation this thought might initiate some rethinking of LMS functionality. In the following the asymmetries in power relation play a major role for the arguments to rethink the technology and practice.

Privacy and Data Protection Guidelines

The legislation from its beginning in the 1970s had a perspective first on the (power) relations between public authorities and citizens which lead to several principles which are widely used in legislation around the world. In addition the privacy perspective, which respects private spaces in comparison to public spaces, the data protection perspective accepts that the digital representation has effects that may be problematic (unwanted distribution, misinterpretation of mediated data, use in broad calculations for intrusive behavioral models etc.). This paper refers to the 1980s OECD Guidelines for data protection with the following eight principles, which can be used to discuss several practices in the LMSs and need to be considered to become legally compliant:

- Collection Limitation Principle: data collection is only allowed as lawful means for at least fair purposes. Minimizing data collection to the necessary level is a wicked problem due to the needed decision what actually is necessary in comparison to just "helpful" information.
- Data Quality Principle: it requires data processors to take care that data collected is kept accurate, complete and up-to-date.
- Purpose Specification Principle: the purpose of data collection needs to be transparently defined prior to data collection.
- Use Limitation Principle: the use of data is limited to the defined purposes.
- Security Safeguards Principle: technical and organizational measures need to be in place to secure the personal information.
- Openness Principle: that data processing should be made comprehensible to the public.
- Individual Participation Principle: The data subject has the right to get information about which data about oneself is stored.
- Accountability Principle: for all data collections it needs to be made clear who is accountable. For LMS this is mostly regulated in organizational policies.

These principles are useful as analytical categories, but are not easy to translate to system functionality. Approaches for structured methods exist (Spiekermann and Cranor 2009). The background of the LMS as cooperative systems with some specifics induces complexity that leads to perspectives that needs a more detailed analysis and a reference to results from the field of CSCW.

Privacy Improvements to Maintain Trust

Course Based Configuration of Data Recording

One deficit with respect to the aforementioned principle of "*collection limitation*" is that data collection of usage data for awareness mechanisms cannot be configured on different levels: The low level necessities for simple lecture scenarios where the LMS is used just for sharing of presentation slides should be sufficiently

configurable as well as the full featured needs of complex scenarios with teamwork in subgroups etc. Options for configuring the data collection on the course level would already be a big step forward, but it would be even more useful, to bind them to the usage of a specific functionality. So if notification is turned on, the data collection of the specifically needed events for these elements is initiated, otherwise this data will not be logged. From a data protection perspective legitimate data collection is always justified from actual (legitimate) use of the data. And this also is in line to the users' perspective: they do not want to bother which kind of data is needed. They do think from what is needed as a function to fulfill their task.

We evaluated the practical information needs from current use in our study. First we made a course data review looking at actually used functionality in the courses. Secondly we detailed hypotheses and results with three interviews with teaching personnel as well as consulting experts. Our results here are that there are possible groupings of the whole list of functionality which can be differentiated with certain needs regarding personal data. It became clear that the feature driven development and configuration of the systems is problematic. A discussion forum for example is in one pattern used as a personal broadcasting communication channel, disclosing work, detailed times etc. (discussion is part of the personal work assignment) whereas in another scenario it is sufficient to have an anonymous but public communication channel without any further information of user details. For further elaborating on a solution we derived seven clusters of system modules with a proximity in usage grouping functionality like "Lecture support" or "projectbased courses" that can be regularly seen as part of the same usage scenario. Using patterns the configuration process for regularly performed scenarios can be simplified, while justifying the data and information needs from the point of view of these scenarios. Systems may support these standard cases with preconfigured enforced "policies". Each tutor can decide on his practical needs which scenario is acceptable, at the same time adhering to the privacy and data protection requirements. In any necessary case individual solutions remain possible can be implemented after personal consultancy of knowledgeable institutions. The data analysis shows that these are single instances where the higher administrative overhead is reasonable.

Identity Management

In many installations the creation of accounts for system use is not bound to any checking of the identity, which leads to problems regarding identity theft scenarios. This is related to the *data quality principle*. Often one can simply create an account using another students' name and make someone look odd from a teachers' perspective. In open platforms on the web this aspect is negligible, because the primary contact is on the web (with the pseudonyms in discussion forums, wikis and the like). In LMS the primary contact is in the reality, and pseudonyms can be used to mislead the connection between an online and a real identity. The pseudonym "John_Smith" may be controlled from "Eddy Evil" in reality, although a John Smith actually exists in an organization. This may lead to problems when teachers will have to grade students in reality. Therefore it is useful to use identity management and assured authentication within LMS. On the other hand not in all scenarios it is useful nor necessary to know all persons performing actions. Sometimes necessary checks might be reduced to the decision of just checking if someone is allowed. This can be done with anonymous credentials (Welch et al. 2005). One scenario where this might be applied is the download of teaching materials. In many cases it is not necessary to actually know who downloaded the material. With anonymous credentials the access right is checked without knowing the identity at the stage of access (cf. Franz et al. 2006).

Anonymization and Data Retention

In some countries it is legally required to delete data in compliance with a defined process to follow the *use limitation principle*. A student that discussed a topic naively in a first semester course discussion forum should have a chance that these utterances will disappear at some point in time. There are basic legal rules requiring to mandatorily delete data when their purpose is no longer existing according to the *purpose specification principle*. In principle it should be clear at the time of data collection when data will be actually be deleted (or anonymized). "When" refers to a concrete time or a condition mostly bound to a process status. This aspect is not widely thought through in LMS. We found three types of functionality to delete data. First objects can be deleted by a user with the appropriate access rights, e.g. entries in discussion forums can be deleted. Secondly complete courses can be deleted, mostly by administrators. Thirdly courses can be reused by teachers. Supporting this is a definitely necessary functionality and this is usually implemented with a limited transfer. To some extent personal information especially of earlier participants is not transferred to the new course. In some cases one can also find ways to work around these limited options and find a way to delete groups of data, data in a discussion forum etc.

But it is obvious that this limited functionality leads to prolonged storage of data. Deletion on the micro level is usually not available. An example is the timestamp usually written with discussion forum contributions. Although it is helpful to know that an answer actually came seconds ago ("maybe I get a chatting answer, when I give a quick response myself now"), there is very little use of the information at that level of

detail when the responses were days ago. These timestamps document some types of behavior (“Student X usually works at midnight.”). From a privacy point of view this level of detailed data should be avoided.

Systems functionality needs to offer options to configure deletion, data detail reduction or anonymization. One can think of a discussion forum in a LMS about the organization of a course, where comments other than the ones of the teacher are deleted after a configurable time (for example 4 months).

Roles and Privileges

The basic idea of confidentiality is linked to the use limitation principle: each user should only see those data relevant to their task. The translation from the task descriptions to technical roles with privileges is usually done with authorization schemes. These schemes are in comparison to other kinds of systems simple in LMS. Roles in authorization schemes are usually limited to administrators (technical and organizational administrators are usually not distinguished), teachers with full access to their courses and some types of supportive roles: content managers, assistants usually being students. Beyond these basic roles more dynamic roles for access rights need to be considered. Users can be part of a course or of (sub-) group within the course. For all these types of role models access control mechanisms are usually available in the systems.

From a cultural differences perspective it is interesting to see that in some systems a “parents’ view” is implemented, allowing parents to view the workspace of their children. If this is allowed or necessary access seems to depend on the age of students. In higher education there is no use for this kind of backdoor access. The access of parents also is hidden from the students. From a privacy point of view this is in any case contradictory to the general principles. Another type of hidden account with a false identity is often used for checking the students’ perspective on the configuration.

But the main deficit is coming from the fact that in practice the available access control functionality with their roles and mechanisms are simply not applied. Professors take for granted that their responsibility lead to full permissions although it is rare that they actually perform tasks themselves. Instead student assistants are active in the LMS and perform tasks like updating course information, uploading presentations and other material or making test results available. But those assistants should act in the background, but should have full access. We found that all administrative actors in the LMS have full permissions to the course information. The problematic constellations arise from identities being assistants as well as fellow students that regularly happen. They have access to detailed information (marks, contributions) about their fellow students. This becomes especially problematic, when this access is also hidden, so that a student cannot even know, that a colleague knows these details. General privacy guidelines require to select specific roles with limited privileges and specific restrictions in this case. But the existing technical options are not widely used. An analysis of the actually used roles showed that within 2194 courses at our University 33% had more than one lecturer with full access. On the contrary only 21% used roles with limitations. At that time it was also possible and regularly reported that passwords were passed on, so that there were even more courses managed by more than one user with full access. Responsible people from other universities in Germany supported these figures from their experience.

To overcome these deficits first there are policies needed. But secondly the reasons are also grounded in technological obstacles. For example users cannot foresee the results of specific selections for access control. Since it is much easier to select full access – there will never be a problem that the assistants have access problems – those are selected. It has to be easier to see which limitations are bound to a certain role, what can be done with this role and from a usability perspective there might be specific views to support the respective tasks of the role more efficiently than with the general roles. If it would be easier to predecide, whether a problem might really occur or not, decisions about privileges might be made more reluctant.

Visibility in LMS: Public and Private Spaces

Linked to access privileges is a view on the LMS rethinking their conception of place and space (Snowdon and Munro 2001). LMS should support learning. So far the idea behind most LMS is that learning happens best under the guidance of a teacher in the classroom. But this is also sometimes perceived as under the control of a teacher. The systems are conceptualized as a replacement of the classroom or an extension of it. In all times at schools and universities learning also happened in solitude and between uncontrolled groups of learners. LMS tend to control these places of learning. This contributes to students evading to other platforms out of sight of teachers. Assuring private and closed peer group spaces in LMS’s may bring some of the students back and may make some of the “stupid questions” visible, because the teacher is closer. To reach this we need a trustable environment first. We see a strong link to the openness principle and the discussed topics of power relations.

Openness and Power Relations

A different approach would be that in principle the groups with lesser power (students) are allowed to see behavior of the one with power (teacher). This may seem odd at first. The consequences would be twofold: Firstly teachers may reduce problematic behavior since it might become visible, and might be interpreted as

misuse. Secondly students will get an impression of what actually goes on behind the scenes. When the system itself is open, transparent and trustable it will also create trust to the teacher. Access limitations or gatekeeper-models to possibly problematic functionality is no longer needed, because teachers will reduce possibly problematic behavior themselves. This is similar to the equivalence principle which was developed in the CSCW discussion and which was based on more or less symmetrical power relations. In LMS this is not the case. In some cases the “symmetry” assumption can be displaced in “asymmetries with a controlling public”. A group of people can create a kind of open public, they can build alliances, so that a power asymmetry should often be overcome and become less problematic with respect to the privacy discussion. Of course in one-on-one situations this kind of transparency may also be considered harmful with respect to privacy.

Conclusions

This contribution should have made clear that there is a great potential to improve LMS with respect to privacy and data protection. On the one hand laws may give reason for these improvements. Laws and culture are different in countries, so that this is sometimes considered a low priority. On the other hand we see that a learning and education culture based on trust between actors is a desirable goal. The respect for privacy is part of such a culture. Setting up an agenda with priorities for improving LMS, it would look like this:

1. The data collection should be configurable and adjusted to the necessities of the current practice of actual e-learning based courses and lectures. This could be eased by example scenarios with privacy aware configurations
2. Deletion, Anonymisation and data granularity reduction should be applied where possible and made transparent to the users to enhance motivation.
3. It should be visible which data is stored and visible in the platforms to the individual users.

All mentioned improvements are not new from a technological standpoint, but privacy needs higher priority to become implemented. Legal requirements are only one possible reason to pay attention to privacy and data protection, another is students’ motivation. “The stupid questions are asked elsewhere anyway.”- Learning more about these stupid questions is learning about one’s own failures in teaching and helps to improve. Students trust in the privacy of learning platforms is a basis for a feeling for a safe learning environment. Rethinking this may lead to an environment where questions may be asked, teachers never heard before.

References

- Bellotti, V.; Sellen, A. (1993). Design for Privacy in Ubiquitous Computing Environments. Third European Conf. Computer-Supported Cooperative Work ECSCW'93 (Milano, Italy), 77-92. Dordrecht, Kluwer.
- Brookfield, S. D. (1990). The skillful teacher. San Francisco: Jossey-Bass.
- Clement, A. (1993). Working in (and on) the Electronic Fischbowl? Privacy Aspects of Multi-Media Communications. NetWORKing 1993. pp.123-132
- Culnan, M. J. & Carlin, T. J. (2009). 'Online Privacy Practices in Higher Education: Making the Grade?', Commun. ACM 52(3), 126-130.
- Eckert, C. (2003). Sicherheit und E-Learning. Beitrag zum Workshop „E-Learning: Beherrschbarkeit und Sicherheit“. TU Ilmenau. Juli 2003.
- Eibl, C.J.: Privacy and Confidentiality in E-Learning Systems (2009). In: Perry, M.; Sasaki, H.; Ehmann, M.; Ortiz, G.; Dini, O. (Eds.): Fourth International Conference on Internet and Web Applications and Services (ICIW 2009). IEEE Computer Society Press, Mai 2009.
- Franz, E., Böttcher, A., Wahrig, H., Borcea-Pfitzmann, K. (2006). Access Control in a Privacy-Aware eLearning Environment. In: Proc. of AREs 2006 Workshop on Security in eLearning (SEL), Vienna, 2006.
- German Constitutional Court (1984). Court Decision: “BVerfGE 65, 1 – Volkszählung”, 1984.
- OECD (1980). OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data. OECD - Organization for economic cooperation and development. 1980.
- Rezgui, A.; Bouguettaya, A.; Eltoweissy, M. (2003). Preserving Privacy in the Web: Facts, Challenges and Solutions. IEEE Security & Privacy, Vol. 1, No. 6/2003.
- Welch, V., Barton, T., Keahey, K., Siebenlist, F. (2005). Attributes, Anonymity, and Access: Shibboleth and Globus Integration to Facilitate Grid Collaboration, Proc. of the 4th PKI R&D Workshop, 2005.
- Spiekermann, S. & Cranor, L. F. (2009). 'Engineering Privacy', IEEE Transactions on Software Engineering, 35(1), pp 67-82.

Acknowledgments

The authors have to thank Marco Ibscher, Volker Riedel and Holger Hansen for their contributions and their dedicated participation in this effort.

Virtual Social Competence Instruction for Individuals with Autism Spectrum Disorders: Beyond the Single-User Experience

Matthew Schmidt, James Laffey, Janine Stichter, University of Missouri, 303 Townsend Hall Columbia, MO 65211

Email: schmidtma@missouri.edu, laffeyj@missouri.edu, stichterj@missouri.edu

Abstract: While the potential of three-dimensional virtual learning environments (3D VLEs) has been recognized for individuals with Autism Spectrum Disorders, little research exists on the use of collaborative, multi-user three-dimensional virtual learning environments for teaching social competence to these individuals. This paper reports the results of study which aimed to gain an understanding of four participants' interactions in the medium by exploring the extent to which participants engaged in appropriate and inappropriate reciprocal interactions as they took part in a single unit of a five-unit social competency curriculum provided via the 3D VLE. Findings indicate that participants took part in reciprocal interaction, the majority of which were verbal responses, that these interactions were predominantly socially appropriate and that they share some similarities with real-world interactions reported in other studies.

Introduction

Interest in collaborative virtual environments as a viable medium for delivering online instruction is growing among educators and researchers. Systems such as Quest Atlantis (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005), Whyville (Neulight, Kafai, Kao, Foley, & Galas, 2007) and River City (Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005) are currently in use and under investigation in a number of school districts. Early research results indicate that these environments can be highly engaging (e.g., Dede et al., 2005; Squire & Jan, 2007) and have the potential for students who use them to show learning gains (e.g., Barab et al., 2005). Interest in these learning technologies is also growing among educators who address special needs populations. In the special needs area of Autism Spectrum Disorders (ASD), practitioners, researchers and technologists are starting to advance the notion of using three-dimensional virtual learning environments (3D VLEs) for social competence instruction.

Individuals with ASD often have social deficits which can result in problematic behavior (National Research Council, 2001; Sasso, Garrison-Harrell, McMahon, & Peck, 1997). Social competence instruction shows promise for remediation of these individuals' social deficits (Stichter, Randolph, Gage, & Schmidt, 2007); however, as we discuss later, access to such instruction is limited, and providing access can be challenging. 3D VLE technology, however, holds promise as a collaborative learning tool which can broaden access, reduce implementation challenges and be leveraged to specifically address the needs of learners with ASD. Evidence to date indicates that individuals with ASD undertaking social competence instruction in 3D VLEs show gains in performance (Leonard, Mitchell, & Parsons, 2002; Mitchell, Parsons, & Leonard, 2007; Moore, Cheng, McGrath, & Powell, 2005; Parsons, Leonard, & Mitchell, 2006; Parsons, Mitchell, & Leonard, 2004, 2005; Rutten et al., 2003). However, the appeal of 3D VLEs as a promising medium for delivering online social competence instruction is tempered by limited knowledge regarding use of these environments and how use impacts interaction and learning. Further research into fundamental issues pertaining to individuals with ASD using 3D VLEs for social competence instruction is needed to better understand how the design of these environments might impact learning outcomes.

The majority of existing work in this field focuses on single-user experiences of practicing discreet skills and does not consider how such instruction might be experienced mutually by multiple users, nor the impact of adding a collaborative dimension to the experience on design, implementation and learning outcomes. We argue that multi-user, Internet-based 3D VLEs have potential to provide access to intervention, qualified guides and social cohorts while maintaining a focus on essential features of social competency instruction in an engaging, highly social and collaborative context. However, little evidence exists to support this assertion. To explore this potential, a virtual world was developed and a research study conducted with individuals with ASD. The goal of the study was not to assess learning outcomes, but rather to explore the nature of participants' interaction in the 3D VLE and to identify to what extent and with what variability participants engage in socially appropriate and inappropriate reciprocal interaction while taking part in instruction in the medium.

Conceptual Framework

Individuals identified with high functioning autism (HFA) or Asperger's Syndrome (AS) are typically characterized as having a desire to be social (Myles & Simpson, 2002), but lacking sufficient social competencies to do so. Emerging research indicates that interventions which specifically target acquisition of social competence can help remediate these deficits (Solomon, Goodlin-Jones, & Anders, 2004; White, Keonig, & Scahill, 2007); however, access to evidence-based interventions is limited and problematic. Training, budgets and organizational factors can affect the intervention (see Gresham, Sugai, & Horner, 2001), and the decontextualized nature of many such interventions has been found to impact their success (Gresham et al., 2001). Additional issues arise when considering delivery to rural areas, low-income school districts, home-schooled students, etc. 3D VLEs may provide an effective medium for delivery of social competence instruction and have unique characteristics which hold promise for approaching access and delivery issues associated with traditional interventions.

The notion of using 3D VLE technology for treatment of ASD emerged in the mid-1990s with the notion that virtual reality might be useful for treatment because it allows for control of input stimuli, modification for generalization, safer learning situations, primarily visual worlds, individualized treatment and responsiveness to computer technology (Max & Burke, 1997; Strickland, 1996, 1997; Strickland, Marcus, Mesibov, & Hogan, 1996). These traits are of importance for individuals with ASD because of these individuals' need for highly individualized instruction, their characteristic rigidity and difficulty generalizing skills between contexts and the tendency for these individuals to be bullied. Findings from this early work provided some support for the proposed benefits but were preliminary and inconclusive. Much of the literature that follows this early work focuses on design issues and justification for using 3D VLEs (Charitos et al., 2000; Dautenhahn, 2000; Kerr, Neale, & Cobb, 2002; Max & Burke, 1997; Parsons et al., 2000; Parsons & Mitchell, 2002).

A cadre of studies conducted at the University of Nottingham through the AS Interactive project provides some initial support for the use of 3D VLEs for facilitating learners' acquisition of social competence. Researchers maintain that virtual environments offer an ideal platform for realizing cognitive approaches because the technology can provide stability, predictability and familiarity, and because it is adaptable to individual needs (Parsons et al., 2000, Parsons & Mitchell, 2002). Findings provide preliminary support for these assertions. Moore and colleagues (2005) found that participants were able to recognize facial expressions in avatars in a VLE. Leonard, Mitchell and Parsons (2002) found significant improvements in participants' ability to make social observations in identical contexts, but noted difficulties in generalization. Rutten and colleagues (2003) found that participants could learn a skill in a 3D VLE and could apply this learning to a video clip depicting a similar context, providing some evidence that skills acquired in the virtual environment may indeed generalize to other contexts. However, all researchers caution against using 3D VLE technology as a stand-alone intervention. In a 2006 study (Parsons et al.), the researchers found that participants appeared to interpret virtual scenes meaningfully, that they could provide examples of how what they learned in 3D VLEs had helped or could have helped them in the real world and that they valued the learning that happened in the 3D VLE. In a later study (Mitchell et al., 2007), the researchers found evidence of improvement in judgments and explanations about social situations using both 3D VLE and video technologies depicting different contexts. However, a weakness that Parsons, Mitchell, and Leonard found in previous work (2004, 2005) was that the majority of their participants engaged in off-task behavior and displayed a limited understanding of the VLE. They hypothesized this was due to low verbal IQ and weak executive functioning.

The Social Dimension

Single-user 3D VEs allow for structured, controlled training environments (Charitos et al., 2000) but only allow for a limited range of activity, interaction and communication possibilities. Multi-user virtual environments (MUVes) allow for a broader range of activity (Ducheneaut, Moore, & Nickell, 2007) and may provide for a less intimidating medium for practicing activities (Cobb et al., 2002). However, little is known about using MUVes for this purpose. Most research focuses on individuals working with a facilitator at a terminal and does not explore how multiple users might mutually interact within 3D VLE systems. Multi-user VLEs can allow peer groups and a facilitator to discuss social competence collaboratively (Cobb et al., 2002; Kerr et al., 2002) and are flexible in that social norms can be negotiated and developed between users (Parsons et al., 2005). However, research has yet to emerge supporting these claims. Given the espoused benefits and increased flexibility of multi-user 3D VLEs, further investigation is needed. To this end, we built a multi-user 3D VLE named iSocial. iSocial is a 3D-VLE-based intervention for social and behavioral outcomes for youth 11-14 years old with ASD. The 3D VLE implementation is an adaptation of a clinic-based curriculum, Social Competence Intervention based on a framework of Cognitive Behavioral Intervention (SCI-S), with demonstrated impact for improving social competence (Stichter, Herzog, Visovsky, Schmidt, Randolph, et al., 2010a). The 3D VLE was designed for participants, in separate locations, to take part in 20 one-hour lessons

with an Online Guide who acted as an instructor. While a comprehensive explanation of the design of iSocial and how it is experienced by youth is beyond the scope of this paper, further information is available in prior publications (Laffey, Schmidt, Stichter, Schmidt, et. al, 2009a; Laffey, Schmidt, Stichter, Schmidt, et. al, 2009b; Laffey, Stichter & Schmidt, 2010b; Schmidt, Laffey, Stichter, Goggins, et. al, 2008).

Methods

A field-test was undertaken to explore how best to study interaction in a multi-user 3D VLE with the specific goal of gaining an understanding of participant interaction in iSocial. The research questions that guided this exploration were: 1) To what extent and with what variability can youth with ASD engage in appropriate reciprocal interaction (RI) in our 3D VLE? 2) To what extent and with what variability do youth with ASD engage in inappropriate behavior in our 3D VLE? To approach these questions, one unit from the SCI-S curriculum was implemented in the 3D VLE and data were gathered. The Turn-Taking in Basic Conversation unit was selected, consisting of four one-hour lessons. Four youth in two groups of two undertook the instruction with assistance by the Online Guide and facilitators who physically sat with them. Two groups were used in order to provide a counterbalanced research design. Participants were between 11-14 years old, had a medical diagnosis of autism determined by the Autism Diagnostic Interview Revised (ADI-R) (Rutter, Le Couteur, & Lord, 2003) and/or the Autism Diagnostic Observation Schedule (ADOS) (Lord, 2002), were verbal/capable of speech and had an intelligence quotient within one standard deviation of the mean for the typical range (e.g., a score of 85-115).

Data were collected at an interdisciplinary autism research and treatment center in the Midwest. The unit of analysis consisted of four one-hour lessons delivered over a two-week period. The lesson activities consisted of the youth having opportunities 1) to learn about social competency through lessons provided by an online guide, 2) to try out and practice the skills in both structured and more naturalistic contexts, and 3) to interact in social ways with peers and the online guide. Video camera recordings showing the users physically at their computers as well as screen recordings were captured. These videos were coded by four trained graduate students based on a reciprocal interaction coding scheme (Laffey, Schmidt, Henry, Wang, et.al, 2010; Schmidt, Laffey, Henry, Wang, et. al, 2010). This coding scheme captured participants' reciprocal interactions (e.g., conversational initiations, responses and continuations), the 3D VLE affordance which made those interactions possible (e.g., verbalizations, avatar gestures) and the curricular context promoting the interaction (e.g., introduction of the skill, verbal practice). These various aspects of reciprocal interactions were coded in tiers in the coding software used, ELAN Linguistic Annotator (<http://www.lat-mpi.eu/tools/elan/>). Upon completion of the coding process, inter-observer agreement measures were calculated for 25% of all videos, with final agreement between coders being 91.3%.

Coded data from ELAN were imported to Microsoft Excel in order to prepare graphical displays of behavior for visual analysis. Ratios of reciprocal interaction behaviors were plotted over time on a graph. The resulting graphs provided an aggregate view of reciprocal interactions in context with reciprocal interaction rates plotted on the Y-axis and corresponding contexts on the X-axis. Following this, percentages of affordance codes were calculated and added to the graph. Percentages of affordance codes were calculated by dividing the sum of specific affordance codes (e.g., gesture) by the total of all other affordance codes. Stacked 100% column charts were then plotted over time, depicting the percentages of discrete affordance codes within lesson context.

The resulting visualizations not only provide graphical depictions of discrete reciprocal interaction behaviors-in-context (e.g., initiation, response, continuation), but also representations of affordance-in-context (e.g., verbalization, text chat, gesture). Contexts are demarcated along the Y-axis, affordance codes are characterized as 100% stacked columns within those contexts and the model of reciprocal interaction is characterized as a line chart within contexts and superimposed on top of the affordance codes' columns. The graphs were used for visual analysis, each visually depicting one participant's coded reciprocal interaction-in-context for a single lesson.

Findings

Graphs were examined across lessons for trends between and within participants. Findings provide compelling evidence to approach the research questions. Analysis indicates on average high (<80%) levels of appropriate reciprocal interaction, but indicates some variation across youth and across context. The data also show that response is the dominant appropriate reciprocal interaction, with the number of continuations being relatively small in comparison to responses. In addition, interruptions are the dominant inappropriate behavior, with all other inappropriate behaviors combined accounting for less than 2% of all interaction.

Across all participants and all lessons, the dominant reciprocal interaction behavior was response. The mean percentage of response across participants and lessons was 55.65%. The second most dominant reciprocal interaction behavior was continuation, with a mean percentage across participants and lessons of 21.06%. Initiation was the least dominant reciprocal interaction behavior, with a mean percentage across participants and lessons of 20.99%. Initiation and continuation are functionally equivalent, with only a .07% difference in

average rate. For some participants (Participants 1 and 2), initiations were on average higher, and for others (Participants 3 and 4), continuations were on average higher. Across participants and lessons, the most dominant form of inappropriate behavior was interruption, with a mean of 9.33% of all reciprocal interaction codes. The mean of all other inappropriate behaviors, aggregated, was less than 1.8%. Breakdowns of average percentages of reciprocal interaction behaviors are provided in Table 1. Figure 1 provides an example visualization illustrating response as the dominant reciprocal interaction behavior.

Table 1: Percentile means of initiations, responses, continuations and interruptions among participants for all avatar treatment conditions.

	Initiations	Responses	Continuations	Interruptions
Participant 1	26.19%	51.03%	21.83%	4.58%
Participant 2	29.09%	45.25%	17.38%	21.08%
Participant 3	8.82%	72.01%	19.17%	2.76%
Participant 4	19.85%	54.31%	25.84%	8.92%

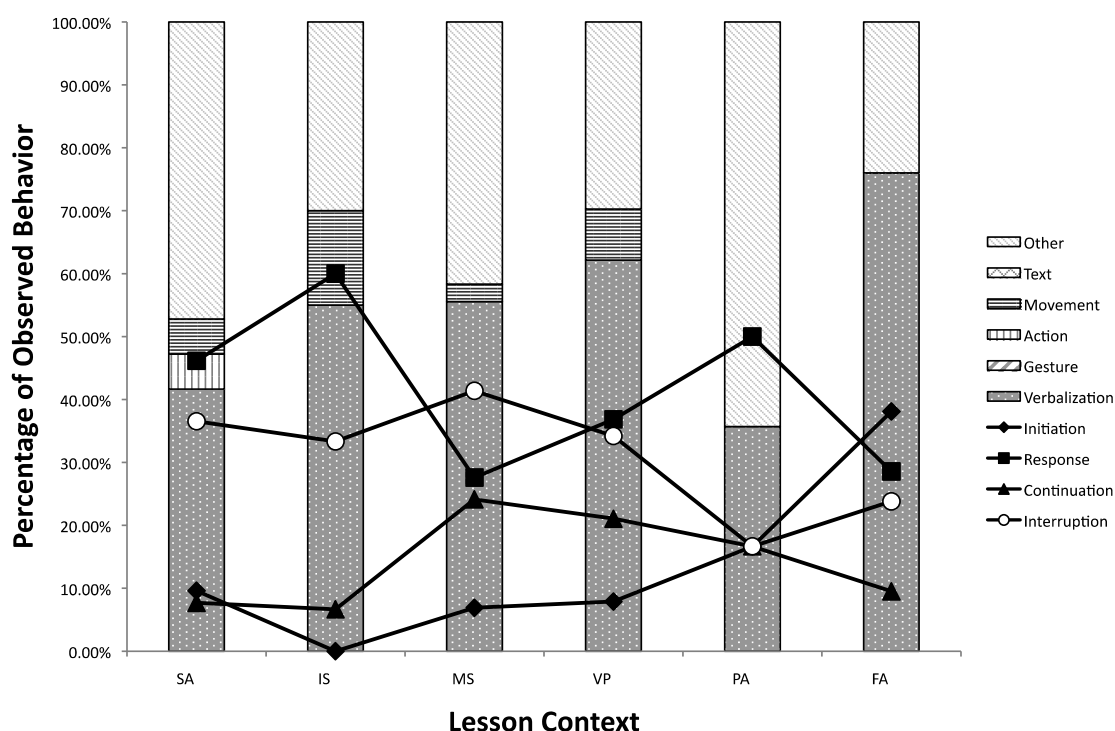


Figure 1. Example visualization indicating response as the dominant appropriate reciprocal interaction behavior and interruptions as the dominant inappropriate behavior. Lesson contexts are abbreviations: 1) starting activities (SA), 2) introduction of the skill (IS), 3) modeling of the skill (MS), 4) verbal practice (VP), 5) practice activities (PA) and 6) finishing activities (FA).

Across all participants and lessons, the dominant 3D VLE affordance used for interacting with others was verbalization. The mean percentage of verbalization across participants and lessons was 51.48%, followed by movement at 7.62%, gesture 5.95% and action at 3.64%. Text was the least dominant affordance, with a mean percentage across participants and lessons of 0.66%. Breakdowns of average percentages of affordance codes are provided in Table 2.

Table 2: Mean percentages of interaction mode codes for all avatar treatment conditions.

	Verbalization	Gesture	Action	Movement	Text
Participant 1	49.41%	3.40%	5.97%	3.91%	0.99%
Participant 2	48.13%	5.23%	6.20%	6.73%	0.46%
Participant 3	47.52%	5.35%	1.77%	14.62%	0.00%

Participant 4	60.86%	9.81%	0.62%	5.22%	1.17%
---------------	--------	-------	-------	-------	-------

Findings indicate that from the reciprocal interaction level of coding, the dominant appropriate interaction behavior was response and the dominant inappropriate interaction behavior was interruption. From the affordance level of coding, the dominant affordance used was verbalization. In other words, participants in the 3D VLE were typically responding verbally, with occasional interruptions.

Discussion

The advancement of research on individuals with ASD using 3D VLE technology indicates high potential and promising, albeit preliminary, results. A weakness of preceding systems is that they were constrained to a pre-programmed single-user experience and that the range of activities and interactions in the environment was very limited and did not share the richness and complexity of natural communication. Drawing from prior research efforts, the current study attempted to further the field in its use of a multi-user 3D VLE for delivering social competence instruction. The goal of this study was to gain an understanding of participant interaction in a multi-user, collaborative 3D VLE by investigating their interactions in the medium. The driving question for this study was whether and to what extent the participants, who are limited in their social competence and have difficulties being social, could act reciprocally when asked to learn together in a 3D VLE. The findings show that participants can indeed interact appropriately, although with occasional episodes of inappropriate behavior.

Generally speaking, participants in the iSocial 3D VLE were responding verbally and their interactions were predominantly socially appropriate. This finding is meaningful not only in that it indicates participants were engaging in socially appropriate reciprocal interactions, but also in that this interaction pattern is mirrored in research on reciprocal interactions of individuals with ASD in the physical world. Findings by other researchers (e.g., Koegel et al., 2001; Roeyers, 1996) indicate that individuals with ASD tended to have lower rates of initiations as compared with rates of responses, and that their interaction tended to be predominantly socially appropriate. That participants in the current study were able to engage in successful reciprocal interactions in the multi-user environment and that their interactions in the environment showed similarities to real world interactions appears to support the assertion that 3D VLEs have the potential to provide a “vehicle for social encounters and social interactions” (Mitchell et al., 2007, p. 599). These findings provide foundational support for future research and lend credence to the notion that using multi-user 3D VLEs for social competence instruction for individuals with ASD is both feasible and socially valid.

Taking a different perspective, consideration must be given to user supports, not only to initiate and maintain interaction, but also to ensure the social appropriateness of interaction. Indeed, Rutten and colleagues (2003) found that participants needed support in initiating and maintaining interaction or else their interaction quickly halted. Prior researchers have cautioned against using 3D VLEs as a stand-alone intervention (Leonard et al., 2002; Moore et al., 2005; Rutten et al., 2003). Nonetheless, interventions like iSocial have the potential to promote changes to educational practices in that they can make evidence-based curricula and interventions taught by highly trained instructors and practitioners widely available to individuals with ASD. While the promise of networked, multi-user 3D VLEs for providing social competence instruction over a distance may seem obvious since this would allow for access to instruction and instructors in underserved areas, consideration should be given to what other supports can promote acquisition of social competence in conjunction with, but outside of, the 3D VLE. Indeed, we have not yet tested the degree to which skills learned in the 3D VLE generalize to real world contexts. While the current study provided some evidence that participants were able to be social in the environment and that the majority of their interaction was positive, it was limited by its small sample size and it did not investigate whether skills generalize to different contexts. Supporting and measuring generalization from the virtual world to the real world is critical if efforts like iSocial are to be successful. This remains an area that is open for further investigation.

References

Due to space constraints, references are included at the following URL: <http://goo.gl/fhdfc>

Acknowledgements

This research was made possible by the generous contributions of the Thompson Center for Autism and Neurodevelopmental Disorders and a grant from our university research board.

Teachers' Interventions and Knowledge Creation in a Master 'Learning & Innovation for Teachers in Vocational Education'

Frank de Jong, Hennie van Heijst, Lia Spreeuwenberg, Hanneke de Laat, University of Applied Sciences and Teacher Education, Churchilweg 68, 6706 AD; P.O. Box 80, 6700 AB, Wageningen, The Netherlands
 Email: f.de.jong@stoashogeschool.nl, h.van.heijst@stoashogeschool.nl, l.spreeuwenberg@stoashogeschool.nl, h.de.laat@stoashogeschool.nl

Abstract: The study concerned students working in the Masters program Learning and Innovation during a year related to three themes. In this master program the principle of knowledge creation is an important pedagogical starting point. Teachers translate the principles in their personal practical didactical handling, which is recognizable in the difference of passive, and active knowledge building activities. These activities do not predict very well the students' activities. Density indications of the student knowledge building community should suggest not being to active and just reading students' notes. However preliminary results of qualitative student conversations suggest the opposite. Analysis indicates an increase in the quality of collective knowledge development.

Introduction

School leaders are confronted with a deficiency in teachers' competence related to their educational knowledge about learning and instruction, and to their research skills for evidence informed process of continuous improvement of educational practice. The two-year Master 'learning and innovating' aims a professional development of teachers in vocational education and knowledge workers who aspire a leading role in the process of educational progression. Students work in communities of practice to prepare and implement an innovation and praxis oriented research, while in blocks of four months developing their theoretical knowledge in knowledge communities concerning topics of team development, educational psychology, teaching (didactics), interpersonal acting, environment awareness and project management. Teaching in the master program is based on constructivist principles. This not only relates to the discussion between constructivism and direct instruction (Tobias and Duffy, 2009), but especially to approach of knowledge building (Bereiter, 2002) and knowledge building principles (Scardamalia, 2002a). Knowledge creation leads to another learning orientation than the traditional 'belief mode' of learning. It leads to a 'design mode' of learning, where ideas are approached as less fixed and given, but more approached by assessing their development potential within the collectively improvement of these conceptual artifacts within and for the community (Bereiter, 2002). Although principles are well described for teachers it is searching how to incorporate them in their style of teaching and student coaching as well to find out what works? A lot of studies on the issues how to structure or to interact more active or indirectly do not focus on the level of the development of professionals. Questions are therefore:

- What is the influence of teacher's role and interventions in this process? Are teacher style differences recognizable in their interaction to students? Do students' activities vary over the theme-periods? Do the teacher interventions predict the students' activities?
- Do students go from a 'belief mode of learning' towards a 'design mode of knowledge creation'?

Method

The study followed students and teachers during a year ecological valid, by intervening as less as possible. Data was registered from log files. Teacher's style and their handling with knowledge building principles come forward from a natural peer session. Students followed three themes. The first one in the period September until December; the second from January until half April, the last theme from half April until end of July.

Subjects

The group under study consisted of 3 teachers and 20 students with a teacher education bachelor grade or equivalent. All students work in vocational education or business (human resource development). Their age ranges from 24 to 57, two thirds are female and the regional spread is great.

The Master Context

Students need to have a minimum of two years working experience and must be involved in a educational innovation activity to enter the part-time master program (20 hours study load a week during two years). Monthly there was a two-day meeting of 'community of learning and knowledge building which included (guest) lectures, workshops, face-to-face knowledge creation conversations. In those two days students also exchanged information and experiences in 'communities of practice' about their ongoing innovative projects and research preparations. In between these monthly meetings, students learned and where engaged in

improving their understanding, their ideas, their knowledge together by conversation on the e-environment Knowledge Forum (KF) (Scardamalia, 2002b).

Data & Analysis

The conversation data in KF is subject of quantitative and qualitative analysis. Three theme periods vary on content, e.g. team development, Educational psychology and Pedagogy, but also in the way teachers intervened e.g. more or less directed and intensive.

Dependent variables where basic knowledge building measures generated by analytic tools embedded in KF: Notes created; Build-ons created; Annotations; Notes read; Notes revisions; views worked in; supports used; Rise-aboves created; problems worked on; notes with key words; keywords used and references created. Measures are also cumulated per theme period as a total measure. Teachers' variables are based on social network analysis (SNA): the number of notes read, build-on student's notes; references created; annotations linked to each student. A split is made by two variables related to notes of students read on the one hand and build-on, reference, and annotations on the other hand per theme period. The SNA also make some density data available.

MANOVA, ANOVA and Regression analysis were done with SPSS. In order to get a sense of how the knowledge creation process evolves and the conceptual quality of the discussions progresses, qualitative analysis of the database is carried out in addition. Four knowledge conversations in KF are subject of these analyses. The analyzed knowledge conversations had approximately equal size (average of 9 contributions). Besides the size also persons' ego-network strength at the end of the first period was a criterion. The conversations relate to the three themes. The qualitative analysis concerned: 1). *Propositional/conceptual analysis*: displaying the content at the level of key concepts and propositions (relations between concepts) in the form of concept maps (Novak & Canas, 2008). This analysis is limited to propositions around key concepts related to first 2 theme periods 2). *Socio-affective and regulative aspects of the contribution*: utterances of interpersonal nature that accompany the cognitive component of the contributions (the propositions) or regulate/direct the conversation (Kleine Staarman, 2009). 3). *Analysis of the perspective or context* from which participants derive their propositions and which gives 'weight' to their contributions. E.g. explicit references to literature, referring to implicitly assumed collective knowledge, private or personal experiences or opinions, the context of their work place or their study and contributions of earlier date by themselves or classmates.

Instruments

Knowledge Forum is an asynchronous computer mediated communication (CMC) technology that supports the processes of knowledge building (KB). It facilitates collaborative knowledge-building strategies, textual and graphical representation of ideas, and reorganization of knowledge artifacts (Scardamalia, 2004). KB is a process of creating, testing, and improvement of ideas, e.g. conceptual artifacts. Scardamalia (2002) proposes 12 principles of KB: Real ideas and authentic problems; Improvable ideas; Idea diversity; Rise above; Epistemic agency; Community knowledge, collective responsibility; Democratizing knowledge; Symmetric knowledge advancement; Pervasive Knowledge building; Constructive uses of authoritative sources; Knowledge building discourse; Concurrent, embedded, and transformative assessment. Contributions can start from a new question or idea or build on previously placed contributions or to 'rise aboves'.

Teachers

The KB-principles guided teachers with respect to their personal style. During a collegial session teachers who did not yet teach in the master program interviewed their peers on how they handled the principles. Interviews where recorded, noted and analyzed collectively. Secondly the conclusions where checked on basis of principles description (Scardamalia, 2002a) and a characterization was setup. The latter was checked by the teachers if it reflected their teaching. (see table 1). The characterization shows that the teacher of team development facilitated more at the background. The educational psychology teacher has more structuring and student challenging interactions and the teacher of the didactical theme is even more directed on structuring and building on student's ideas.

Table 1: The teachers' actions related to the knowledge building principles.

KC Principles (Sardamalia)	Team development 'more at the background facilitating'	Educational Psychology 'more structuring and challenging interactions'.	Pedagogy, Instructional design 'Jig saw approach'
Real idea, authentic problems	Students' authentic questions are leading;	Development of your own vision is leading	Question: How to organize and facilitate learning in education and how to facilitate this in the professional situation.

Improvable ideas	Every idea is worth full and can be build on; student directed	Care about safety in the group to build on	Professional product oriented: curriculum analysis; advice; colleague study day
Idea diversity	Ordering of ideas, breadth of ideas and new information;	Building on student's notes by suggesting, explicating contradictions	Building on a pre-structured visualized mind map
Rise Above	Guiding writing a paper F2F	Working on a vision; separating main en side issues; building mental and a theoretical model	Refining the mind map
Epistemic agency		Self responsibility	
Community knowledge	During month of the Studium	Collective responsibility	Collectively exchange with colleagues
Collective responsibility	Networking outside curriculum activities	Group responsibility, stimulating use of sources; critical peer reflection	Jig saw groups
Democratizing knowledge	Studium	Studium	Studium; organizing a study day for colleagues
Symmetric knowledge advancement	Interaction with guest speakers	Sharing of knowledge, sources and ideas	Preparation and results reflections in relation to guest speakers
Pervasive knowledge building	Searching to students' own problems		Meetings at students' workplaces
Constructive use of authoritative sources	Guest speakers also afterwards	Curriculum literature	Literature guest speakers (the author of the core book in the course)
Knowledge building discourse	KC-talking during F2F meetings	KC-structuring in F2F and KF	KC-structuring in F2F and KF
Embedded and transformative assessment	Clustering of notes Face to face discussion to create a rise above	Feedback to improve notes, feed forward by opening perspectives	Strong interventions in KF (content, refering advice, regulating on idea diversity and autoritive sources.

Results

Are Teacher Style Differences Recognizable in Their Interaction to Students on Bases of the SNA-data?

On the teacher data a GLM repeated measurement was carried out with Theme, Teacher and Amount of reading students' notes and Amount of Building on/referring on students' notes as within variables. The analysis revealed a significant main effect for Reading ($M=15$; $Se= 2,06$) and Building ($M=8$; $Se=.14$), $F=54,3$; $1,18$; $P<0.001$). (see fig 1 and 2). The fact if teachers were active teaching in a theme-period has a significant effect on their activities which is revealed by a significant interaction of Theme and Teacher Green house-Geisser $F=12,44$; $4,18$; $P<0.001$). Mauchly's test indicated a violation of sphericity $\chi^2(9)= 54,3$; $P=0.000$). Multivariate test was significant Pillai's Trace $F=9,08$ (4,15); $P=0.001$). So probably difference between themes is significant. The amount of teachers' reading and building-on depends on the fact if they are active teaching in the theme-period or not, as is revealed by the interaction effect between Theme and Read/Build-on $F=3,35$ (2,18); $P<0.05$. This later effect is not equal for each teacher as is indicated by a significant interaction effect of theme, Teacher, Reading/Buildon Greenhouse-Geisser $F=8.73$ (4,18); $P,0.003$). Mauchly's test indicated a violation of sphericity $\chi^2(9)= 54,3$; $P<0.001$). Multivariate test was significant Pillai's Trace $F=9$ (4,15); $P=0.001$). So it is realistic to be confident that the interaction effect is significant. Teacher reading

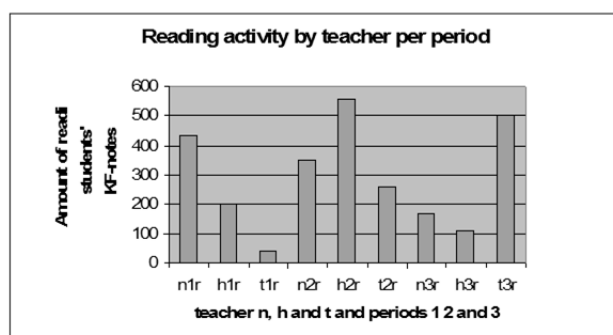


Figure 1. Teachers' Students' Notes Reading per Theme-period.

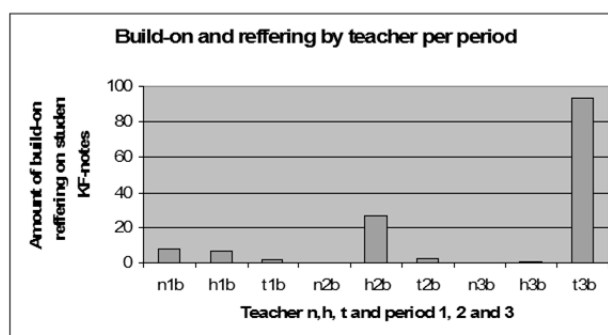


Figure 2. Teachers' Building-on and Referring on Student's Notes per Theme-period.

$M_{\text{theme1}}=50.05$; $Se=7,55$; $M_{\text{theme2}}=45,77$; $Se=7,55$; ; $M_{\text{theme3}}=42,22$; $Se=7,55$ and Teacher buildon/referring ; $M_{\text{theme1}}=0,42$; $Se=0.78$; ; $M_{\text{theme2}}=1,84$; $Se=0,78$; ; $M_{\text{theme3}}=5,21$; $Se=0,78$.

Do Students' Activities Vary over the Theme-periods?

On the teacher data a GLM repeated measurement was carried out with Theme as within factor and 12 knowledge building activities: notes contributed; build-on; annotations; note read; note revisions; views worked in; supports used; rise above; problems worded in; notes with keywords; references created. There was a main effect of Activities (Greenhouse-Geisser $F=69.62$ (11, 29,268); $P<0.001$). Mauchly's test indicated a violation of sphericity $\chi^2(65,252)= 514,25$; $P<0.001$) for activities. The multivariate test was significant Pillai's Trace $F=11,055$ (11,6); $P<0,004$). Activities also vary per theme as is indicated by an interaction effect theme x activities ($F=2,82$ (22,352); $p<0,001$).

Do the Teacher Interventions Predict the Students' Activities?

Three stepwise multiple regression analysis were carried out with as dependent variable the Total students' activities per theme and the independents the teacher Reading activities and Build-on/referring activities. Concerning the first theme the activity of theme1-teacher was not in the model. In the model was the reading activity of the Theme2-teacher: Constant $B=272,94$; $SE B= 53,94$; Theme2-Teacher Reading activity $B=11,03$; $SE B=4,21$; $\beta=0,55$. $R^2=.30$ for step 1, $\Delta R^2=.30$ ($F\text{-change}=7,12(1,17)$; $P<0.02$; Durbin Watson 1,98). Concerning theme 2 also the activity of theme2-teacher was not in the model. . In the model was the reading activity of the Theme3-teacher: Constant $B=134,32$; $SE B= 68,41$; Theme2-Teacher Reading activity $B=18,17$; $SE B=4,29$; $\beta=0,73$. $R^2=.53$ for step 1, $\Delta R^2=.53$ ($F\text{-change}=17,92$ (1,16); $P<0.01$; Durbin Watson 1,91). Only in the third theme the activity of theme3-teacher was in de model, both reading and build-on/referring activities the later with a negative relationship. Step one: Constant $B=84,41$; $SE B= 48,91$; Theme3-teacher activity Reading students notes:; $B=12,23$; $SE B=1,35$; $\beta=0,91$. Step two: Constant $B=97,47$; $SE B= 42,05$. Theme3-teacher activity Reading students notes:; $B=15,33$; $SE B=1,65$; $\beta=1,15$; Theme3-teacher activity build-on/referring on students notes:; $B=-19,03$; $SE B=7,22$; $\beta=-,325$. $R^2=.89$ for step 2, $\Delta R^2=.05$ ($F\text{-change}=6,95(1,15)$; $P<0.02$; Durbin Watson 1,6).

Socio network analysis (SNA) were carried out per theme-period on the variables Reading each other notes, Build-on, Reference and Annotation. A second without Reading notes. Actually the high density is getting less during the year despite that teacher's activities of theme3-teacher predicts better students' activities.

Table 2: Density indications of the student teachers community per theme-period.

Theme	Network edges	Density	Connected to	Level read	Level build-on	Level reference	Level annotate
1	227	98,26%	52	101	5	3	1
2	208	90,04%	57	68	8	2	1
3	181	78,35%	0	135	8	7	1
1 no reading	95	41,12%	7				
2 without reading	80	34,63%	17				
3 without reading	64	27,7%	0				

Do Students Go from a 'Belief Mode of Learning' towards a 'Design Mode of Knowledge Creation'?

Qualitative discourse analysis were carried out to gain more insight in the process of knowledge creation and a potential move towards a design mode of learning. Four conversations were selected of three students on basis of the density of their ego-network. The qualitative analysis of the three knowledge conversations shows that the conversations related to Educational psychology in contrast to team development the number of words per contribution and the number of propositions increased, although the number of participants decreased to four (compared to four and nine related to team development). Moreover, in contrast to the first period (team development) the contributions related to Educational psychology no longer include attachments without added writing about the core message of it by the student. So students articulated more the essence themselves. It is also noticeable that almost all students' contributions enclose regulative and affective expressions. It is also remarkable that the student who started the conversation with a 'new contribution' also contributed a kind of reflective, evaluating contribution at the end. These shifts indicate a move towards a design mode of learning.

The conversation related to Educational psychology shows a clear distinction: students succeed to build complex relations between the different contributions of themselves and that of others during the conversation.

The analyses conversation related to the third team clearly started with a mandate by the teacher. There is more intensive teacher coaching. Students did not build on the four interventions of the teacher. More resources were used in argumentation and less opinions. No attachments were added in the notes in order to 'transfer' any content. Scaffolds do not always correspond with the nature of the contribution. It looks like if there is a relation between the portion of contributing to the community, collective knowledge development and the amount of social and regulative comments. Students who contribute a lot of propositions do this by simultaneously contributing social-affective and regulative comments (see fig. 3).

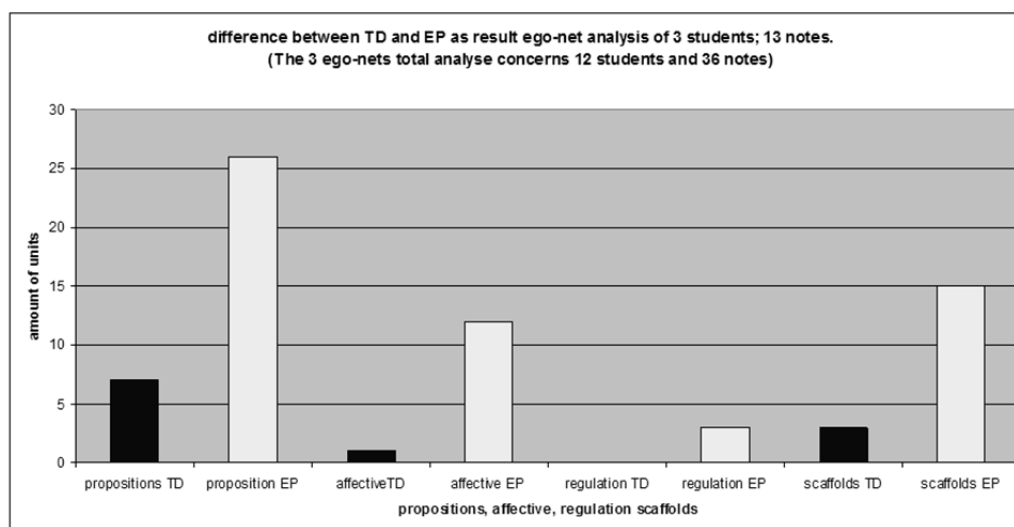


Figure 3. Difference between Propositions, Affective and Regulative Comments and the Use of Scaffolds.

Conclusions

Students' basic knowledge building activities varied across theme-periods during the year. Students' activities are not very well predicted by the teacher activities 'reading student notes' of the actually teaching teacher but more by the reading by other teachers. This might be due to the fact that the other teachers are also mentor of students. This is weird while reading is a rather passive invisible activity. However it might be that in the face-to-face meetings students recognize teachers show their knowledge of the notes in their teaching or mentoring. Only in case of the third teacher his activities predict the student activities. But the more direct activities of build-on and referring have a negative relation with it. So the more building-on and referring as a teacher do, have a decreasing effect on student activity. This is in line with the density of the student community, which is most dense in the first theme-period and decreases the more the teachers are active during theme period 2 and 3. So one could advice to be more at the edge of the community as a teacher. The preliminary qualitative knowledge building conversation analyses however show the opposite. The more the teachers are active the conversations show a deeper level and students move towards a design mode of learning. We concluded that the quantitative results are not directly interpretable in a one to one relation to the quality of knowledge building. More study and analysis are needed to shed light on this relationship.

References

- Bereiter, C. (2002). *Education and Mind in the Knowledge Age*. Mahwah, New Jersey, London; Lawrence Erlbaum Associates, Publishers.
- Kleine Staarman J. (2009). *Collaboration and Technology: The nature of discourse in primary school computer-supported collaborative learning practice*. (Doctoral dissertation). Radboud University, Nijmegen.
- Novak, Cañas, J. (2006) *The Theory Underlying Concept Maps and How to Construct and Use Them*, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida: Institute for Human and Machine Cognition. Retrieved from <http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf>
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.) *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.
- Scardamalia, M. (2002b). CSILE/Knowledge Forum®. In A. Koval Chick & K. Dawson (Eds.) *Educational Technology: An encyclopedia*. Santa Barbara: ABC-CLIO.
- Tobias, S., & Duffy, T. (2009). *Constructivist theory applied to instruction: success or failure?* New York: Routledge.

Using Online Communication Tools to Mediate Curriculum Development As a Collaborative Process

Lei Liu, Susan Yoon, Graduate School of Education, University of Pennsylvania,
Email: leil@gse.upenn.edu, yoonsa@gse.upenn.edu

Abstract: Online professional learning communities provide opportunities for teachers to leverage the capacities of Web 2.0 tools to engage in professional learning, access a network of professionals with shared interests, and to practice media literacy skills that transfer into classroom pedagogy. However the research literature related to teacher collaboration in online learning environments is sparse. This paper addresses this gap and reports on a study that explores features of teacher collaboration in an online community during a curriculum professional development workshop. The findings of this study show that the online professional community provides opportunities for teachers to share situated and distributed cognition and implies that further scaffolding interventions are needed to promote joint work among teachers.

Over the past decade, teacher professional development has shifted from traditional instructor-centered workshop models towards models that involve various types of professional collaboration among teachers. Collaboration is increasingly central in emerging professional learning communities. With the advent of Web 2.0 technologies, a growing body of research has emerged with respect to developing online professional learning communities to provide collaboration opportunities for teachers' professional practices, such as curriculum development. It is reported that online professional learning communities provide opportunities for teachers to leverage the capacities of Web 2.0 tools to engage in professional learning, access a network of professionals with shared interests, and to practice media literacy skills that transfer into classroom pedagogy (Dede, 2006; Owston, 2009). However the research literature related to teacher collaboration in online learning environments is sparse, thus the nature of teacher collaboration within these environments is poorly understood. This paper addresses this gap in the literature and reports on a study that explores features of teacher collaboration in an online community during a curriculum professional development workshop. The purpose of this study was to characterize the nature of teacher online communication interactions toward building curriculum and to shed light on the elements that need to be redesigned to better support teacher collaboration. Several data sources were collected to address the following three research questions: 1) What are the patterns of teachers' online communication? 2) To what extent does teacher collaboration exist in the online community particularly with a goal of constructing science curricula? 3) How does the online communication contribute to their curriculum construction?

Conceptual Framework

Curriculum Development as A Collaborative Process

While more national organizations are calling for the teaching of 21st Century skills and the shift to a learning community framework, teachers need to understand and use collaborative learning processes themselves before expecting it of their students, and to practice those skills in their professional practices such as curriculum development. Studies have demonstrated that teacher collaboration in curriculum development benefits both teachers and students (Hill, 2007; Pounder, 1999). Pounder (1999) compared teachers who worked collaboratively on curriculum design with teachers working independently and found that teachers in collaborative teams reported higher levels of professional growth satisfaction, internal work motivation, and teacher efficacy. Hill (2007) found that students in the classrooms of teachers who collaborated in curriculum design significantly outperformed students in the classrooms of teachers working individually.

Online Professional Learning Community

According to Stoll et al. (2006), professional learning communities often involve a group of professionals sharing and interrogating their practice in an ongoing, reflective, collaborative, inclusive, learning oriented, growth-promoting way. The fundamentals of a learning community require interdependence and reciprocity to provide richer contexts for learning to occur, which Selznik (1996) calls *mutuality*. Many current professional development programs aim to close the gap between the current and potential uses of technology for science instruction (Singer et al., 2000). One of the identified characteristics of "high quality" professional development that may better promote teacher learning particularly relevant to the issue of technology integration in science (Garet et al., 2001), is providing support for collegial interactions among teachers. We believe our online professional learning community offers such affordances. Study findings have supported the idea that the cause

of success in an online environment is the establishment of an effective learning community (Palloff & Pratt, 2007). It is reported that online learning communities provide optimum learning conditions where learning is self-directed and balanced with the opportunity for participants to take control of their learning (Hiemstra, 1994). In addition, the asynchronous nature of online learning communities allow flexible times for teachers to share successful stories or useful resources implemented during their professional practices. Such sharing may foster the development of the concept of “Legitimate Peripheral Participation”, where learning is seen as an inseparable aspect of social practice (Lave & Wenger, 1991). In a review of the technologies used within online communities intended to foster teachers’ reflective discourse, Zhao and Rop (2007) identified several key requirements, including low threshold for teacher use of the technology, scaffolds supporting authentic participation and engagement, and less focus on a tangible product as an outcome and more focus on supporting teacher dialogue. In the next section, we will explain how our program attempted to address these requirements for the purpose of promoting collaboration among teachers through developing an online professional learning community.

Method

Context

This study is part of a large-scale curriculum professional development project designed to increase opportunities for students and teachers in underserved schools to learn and apply innovative technology concepts and skills in the science, technology, engineering, and mathematics (STEM) content areas. We held a three-week professional development workshop where in-service modules occurred in the first week, then teachers collaboratively constructed curriculum units based on the requirement of the program framework in the second week, and in the third week teachers pilot taught their units in small groups.

In our study, teachers participated on Google Groups as the tool for their professional learning communications. Google Groups was selected based on the first key requirement by Zhao and Rop (2007) as it affords practical web pages and discussion boards and more importantly it is extremely user friendly and does not require a high threshold of technology skills. To scaffold authentic participation and teacher engagement, we applied several pedagogical strategies to support teacher communications. First, throughout the three-week professional development, all in-service modules embedded the use of online communication. For example, discussion questions were designed for teachers to answer as homework. Second, we modeled how to share documents and resources in Google Groups. For example, all instructors uploaded their instructional materials. These materials were categorized into content, pedagogy, educational technology, information technology, and STEM careers. Third, we emphasized the importance of developing a professional development community and encouraged teachers’ authentic participation and engagement by asking them to share materials, tools, and websites they used in their practices. Finally, we asked all teachers to create a profile page of themselves to promote expertise transparency, which was intended to help teachers locate others in the group who had particular expertise they needed to access.

Participants

Participants of this study are 13 science teachers (6 female and 7 male) teaching 6th – 12th grades in an urban school district located in Northeastern USA who enrolled in the curriculum professional development. Of the 13 teachers, 46.2% were Caucasian, 46.2% were Black, and 7.6% were Asian. The average number of years of teaching experience is 7.38 ranging from 1 to 33 years. They taught courses in the content areas of physical science, biology, chemistry and physics.

Data Sources and Analyses

The major data source to investigate the characteristics of teacher collaboration was their online discussions during the three-week professional development. All discussion threads were collected and were sequenced by posting time. In addition, five teachers’ collaborative curriculum units were explored to look for evidence of information use that emerged from their online communications.

Online Discussion

The unit of analysis of the online discussion was a message. Adapted from Little’s hierarchical levels of collaboration in professional development (Little, 2003), four coding categories were developed for this study to identify the features of teacher online collaboration for curriculum design:

Table 1: Coding categories for online discussion.

Level of Collaboration	Definition
Level 1: Storytelling	Occasional and sporadic content- or pedagogy-related messages posted by teachers in which they exchange practice stories or fragments of ideas.
Level 2: Asking for Help	Messages posted by individual teachers seeking specific help in the online community.
Level 3: Sharing Resources	Messages posted to share materials, resources, and methods with other colleagues.
Level 4: Joint Work	Messages posted by teachers that intend to evaluate or build on a previously posted message.

Each online discussion message was coded in one of the four categories to identify the level of online collaboration during curriculum professional development, and was coded as either initiation (i.e., initiating a new topic) or response (i.e., responding to a discussion topic). The order of the levels represents increasingly more difficult collaborative actions to achieve. The numbers in each level of collaboration were counted and the frequencies of initiation and response codes were calculated. The time of response message was coded as either within 24 hours or after 24 hours. We believe that a timely response to a message is important to sustain a thread in online communication as studies have reported that learners tend to focus most of their attention on new messages (Hewitt, 2005). Finally, themes found in the online discussion were identified for the purpose of curricular unit analysis.

Curricular Units

In total there were five curricular units constructed by five groups of teachers. A content analysis was conducted to see if the information discussed in the online environment was used in teachers' curricular unit construction. For example, if a teacher shared a link to visualize "the powers of ten", we looked through all five units to see if this piece of information was apparent.

Results

Online Discussion

In total, 30 discussion topics and 89 messages were found in the online learning community. Among the 89 messages, there were 30 messages (9 initiated by instructors and 21 by participating teachers) coded as initiation and 59 as response by teachers. Table 2 shows the distribution of frequencies for each level of teacher collaboration. Although all 13 teachers participated in the online discussion, only 8 of them initiated new discussion topics (21 topics in total). Twelve (57.14%) messages were about sharing resources (to which only 2 received responses from other teachers). Six messages (28.57%) belonged in the category of story-telling (to which 3 received responses), and 3 (14.29%) asked for help (to which 2 received responses). All 7 joint work messages occurred when responding to other messages. Finally among the 59 response messages, 53 responses (89.83%) were posted within 24 hrs after the initiation message and only 6 responses were posted after 24 hours. In general, if nobody responded to a message within 24 hours, the thread usually dies.

Table 2: Distribution of levels of teacher collaboration.

Story-telling	Discussion Question	Asking for Help	Sharing Resources	Joint Work
51 (57.30%)	5 (5.62%)	5 (5.62%)	21 (23.60%)	7 (7.86%)

In addition, in-depth qualitative analysis was conducted to further examine the characteristics of teacher communication and two patterns emerged. First, teachers tended not to respond to story-telling and sharing resources messages unless they had specific questions related to the shared information or certain concerns about its classroom implementation. Here is an example:

- Teacher B: Here is a new Powers of 10 video sent via the PSTA. Wait until it loads and then use the slider to move in and out. Starts at the universe and gets VERRRRRRRY small. <http://www.newgrounds.com/portal/view/525347>
- Teacher A: Thank you for this link. I am going to give it to my students to view at home. Unfortunately, the school district blocks it.

Second, asking for help messages and joint work messages seemed to invite more responses. Teachers tended to respond by providing suggestions based on their professional experiences and sometimes built on each other's idea (although not very frequently). The following example shows how teachers responded to Teacher A's help request. Teacher F, C, and H all responded with where nano-scale science content could be aligned with the core curriculum.

- Teacher A: How will this (nano-scale science) fit in with the school district's pacing schedule? How is it coordinated with the PSSA?
- Teacher F: I think that this would fit into the eighth grade introduction to matter unit that has the parts of the atom. I think it would also fit into the cells unit for 7th grade when students discuss parts of a cell and DNA.
- Teacher C: I also think that a very natural place to talk about a lot of what we'll cover will be in the introductory Physical Science unit, where you discuss what technology is, how it is related to science, and how we utilize it.
- Teacher H: I agree about the matter stuff. Also it would work for waves, in particular light.

Evidence of Adopting Shared Information in Online Discussion

We explored all five teachers' collaborative curriculum unit products to look for evidence for assimilation of shared information from the online discussion. We found that many shared resources were used by groups of teachers during their curriculum design activity. As mentioned above, 21 messages were posted to share resources by individuals (including both instructors and teachers) in the online discussion board. We excluded the information provided by instructors and explored those 17 messages shared by teachers as this study focused on teacher collaboration. Within these 17 messages, 20 pieces of shared information were found because one message may have provided several pieces of information (e.g., several links of computer simulations). We excluded 4 pieces of information not directly related to curriculum construction (2 pieces of information about school supply sales; 2 about policies). The remaining 16 pieces of shared information were categorized into the following themes: Educational Technology (7), science lab activities (5), assessment (3), and pedagogy (1). Table 3 shows how many pieces of information were identified in each group unit. All groups adopted at least one piece of shared information and shared information on assessment was most frequently adopted by groups.

Table 3: Shared information adaptation presented in group curricular units.

	Group Unit 1	Group Unit 2	Group Unit 3	Group Unit 4	Group Unit 5
Assessment	1	2	1	2	1
Lab	0	0	1	0	0
ET	1	0	0	0	0
Pedagogy	0	0	1	0	0

Discussion and Conclusion

This study has explored a neglected aspect of CSCL in the literature: the characteristics of teachers' online collaboration in curriculum development. Although using online communication tools for curriculum professional development is generally acknowledged as holding great promise (Dede, 2006; Owston, 2009), the question remains: What works and what doesn't work and why? The result of this study sheds some light on this issue. First, the online learning community provided opportunities for teachers to share situated and distributed cognition (57.30% story-telling and 23.60% shared resources of all messages). The results found in the sharing resources category were surprising. Little (2003) found that among those four levels of teacher collaboration, sharing resources and joint work had more learning potential for teachers, however they were demonstrated much less frequently. We also found that certain amounts of shared information in the online discussion were apparent in all five curricular units, particularly the shared information about assessment. Consistent with Little's finding, we also found it was difficult for teachers to achieve the deep conversations that constitute joint work. Second, we found that interactions in the online discussion were related to the nature of an initiation message. Specifically, asking for help and joint work messages seemed to invite more responses from other teachers in this study while typically no responses followed story-telling and shared resources messages. This is not surprising because questions in asking for help messages might attract others' attention to brainstorm answers and joint work messages that often include evaluation and reference to other people's posts would create common ground for further interactions. Finally, we found that immediate attention was needed to sustain a thread of discussion (89.83% of responses were made within 24 hours after message initiations). This is consistent with what Hewitt (2005) posited that learners tend to focus most of their attention on new messages. The findings of this study indicate that the online professional community has the potential to promote teacher

collaboration for curriculum design purposes and shows that further scaffolding is needed to promote joint work among teachers. The modeling pedagogical component in our program such as modeling how to share resources with others in the online environment was mirrored in teachers' online discussion. This indicates that positive effects may be achieved if we model how to develop joint work conversations in the online environment. The redesign of our next curriculum professional development will incorporate these implications.

References

- Dede, C. (Ed.) (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA: Harvard Educational Press.
- Garet, M.S., Porter A.C., Desimone, L., Birman, B.F., Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.
- Hiemstra, P. (1994). Self-directed Learning. In T. Husen & T. Postlethwaite (Eds.) *The International Encyclopedia of Education*. Pergamon: Oxford.
- Hill, D. (2007). The Mathematics/Science Housing program. *Science Scope*, 31(4), 60.
- Hewitt, J. (2005). Toward an understanding of how threads die in asynchronous computer conferences. *Journal of The Learning Sciences*, 14 (4), 567-589.
- Lave, J. & Wenger, E.(1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press: Cambridge.
- Little, J. W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record*, 105(6), 913-945.
- Owston, R. (2009). Digital immersion, teacher learning and games. *Educational Researcher*, 38(4), 270-273.
- Palloff, R. M. & Pratt, K. (2007). *Building online learning communities: Effective strategies for the virtual classroom*. San Francisco: Jossey-Bass.
- Pounder, D. G. (1999). Teacher teams: Exploring job characteristics and work-related outcomes of work group enhancement. *Educational Administration Quarterly*, 35(3), 317.
- Selznik, P. (1996). *In search of community. Rooted in the Land: Essays on Community and Place*. W. Vitek and W. Jackson. New Haven, Yale University Press: 195-203.
- Singer, M., Marx, R. W., Krajcik, J. S., & Clay-Chambers, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, 35(3), 165-178.
- Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional learning communities: A review of the literature. *Journal of Educational Change*, 7(4), 221-258.
- Zhao, Y., & Rop, S. (2001). A critical review of the literature on electronic networks as reflective discourse communities for inservice teachers. *Education and Information Technologies*, 6(2), 81-94.

Bridging Multiple Expertise in Collaborative Design for Technology-Enhanced Learning

Yael Kali, University of Haifa, Israel, yael.kali@edtech.haifa.ac.il

Lina Markauskaite, Peter Goodyear, Mary-Helen Ward, University of Sydney, Australia,

Email: Lina.Markauskaite@sydney.edu.au, mary-helen.ward@sydney.edu.au, peter.goodyear@sydney.edu.au

Abstract: Designing technology-enhanced learning requires merging technological, pedagogical, and content knowledge domains, and thus often carried out by multi-professional expert teams. However, working in such teams may involve challenges resulting from participants' different knowledge bases and ways of thinking. This research examined the collaborative design process of three teams who were part of a university initiative to develop technology-enhanced learning. We found that each of the teams: (1) suggested design solutions only after extensive group exploration of the various aspects of the problem, (2) made design decisions in a balanced process in which all domain experts were equally involved, (3) appreciated each other's expertise and used team meetings to learn from each other, and (4) carefully provided ideas that were not in their own domain of expertise. The success of the three teams in designing solutions that were based on their shared knowledge is explained in light of the management process of the university initiative.

Introduction

Designing technology-enhanced learning requires merging of knowledge from several different domains. Mishra and Koehler (2006), who studied how teachers integrate technology into their teaching and design, claim that three major knowledge domains are involved in such processes, namely, knowledge about technology, about pedagogy and about content. They describe a unique type of knowledge merging the three, which they name Technological Pedagogical Content Knowledge (or TPCK). Markauskaite et al. (in press) show that when experts collaboratively design technology-enhanced learning, the knowledge they bring to the table goes even beyond TPCK, and involves merging of knowledge about technology with constructs originally described by Shulman (1987), such as knowledge about: (a) curriculum, (b) learners and their characteristics, (c) social, cultural and institutional organization of the environment, and (d) educational purposes and values.

Naturally, when major design endeavors are at hand, and when the knowledge domains involved require high-level expertise, people prefer to work in multi-disciplinary collaborative teams (Bell, Hoadley, & Linn, 2004; Mercier, Goldman, & Booker, 2009). There are many advantages in such collaborative design efforts, however, challenges have also been documented, which may lead to the development of artifacts that lack integration between knowledge domains brought by different team members, or in the words of Winters et al. (2010):

“...each participant may maintain their own disciplinary approach, effectively creating silos within the team that can lead to little or no integration” (p. 234).

Such lack of integration can lead to the development of programs with attractive graphics and state of the art technology, but with low educational value (Goldman, DiGiano, & Chorost, 2009). It can also lead to programs with sound pedagogical ideas that are delivered in a poor and unattractive manner. These incongruent products stem from what might be called ‘*disciplinary cultural gaps*’ or lack of ‘*disciplinary respect*’ between team members. Sometimes they are caused by *imbalanced competencies* within a design team, as described by diSessa, Azevedo, & Parnafes (2004):

“Some teachers found it difficult and sometimes intimidating to participate as equal contributors in a technology-based development process. Technological developers involved with educational implementation often have, in addition to technical competence, considerable experience with instructional design and in mathematics and science as well. This may put teachers in a weaker position in which they do not have authority in technology-related issues, but neither can they act with clear authority with respect to content and educational issues” (p. 121)

The current research examined the collaborative design work of three teams who were part of an initiative to develop innovative technology-enhanced learning resources within a university setting (Ward, Atkinson, & Peat, 2010). The artifacts they designed were: (a) an ePortfolio environment designed to connect between knowledge gained by students in various courses in a nursing program, (b) a Web-based environment

designed to support social-work student reflect on their out-of-campus training, and (c) a Smartphone application designed to assist health-science students explore medical cases,. Each design team came from a different knowledge domain (Nursing, Social Work and Health Science), and consisted of a few academic staff-members (domain experts) and one or two non-academic staff-members (eLearning design experts). The goal of the research was to decipher what makes a collaborative design process a productive one.

Method

We broadly followed an ethnographic case-study approach. About 90% of the teams' meetings were observed over a course of four months, in which a major part of the design work was conducted. Our data includes audio-taped team-meetings, observation-notes, team e-mails, and some interviews.

To answer the above question we: (a) chose the episodes to analyze by identifying sections in which many design decision were made, (b) developed and refined a coding scheme, (c) coded the data, and (d) developed our claims. Our coding scheme combined two frameworks. The first is Mishra & Koehler's (2006) TPCK, which enabled us to characterize participants' contributions in terms of the type of knowledge they brought to the design meeting discussions. The second is a framework described by Damsa et al. (2010) for the analysis of shared epistemic agency in the context of collaborative design. This approach enabled us to distinguish between different types of collaborative knowledge-building activities in the group such as seeking information, sharing ideas, structuring ideas and producing ideas, which Damsa et al. (2010) view as "knowledge related activities of shared epistemic agency".

The combination of the two frameworks enabled us to relate types of knowledge (combinations of Technology, Pedagogy and Content) with the types of knowledge-building activities (Seek, Share or Suggest any type of knowledge). To these two, we added another layer – the contributor of the knowledge (domain expert versus eLearning design expert). However, if we would have taken each and every combination of these three dimensions (for instance one combination is: seeking technological-pedagogical knowledge by eLearning designer), we would have had 42 possible outcomes (7 combinations of knowledge types: T, P, C, TP, TC, PC and TPC; 3 shared epistemic activities: Seek, Share and Suggest; and two types of contributors: Domain and eLearning experts). In order to get a more focused representation, but still get a sense of all three dimensions, we made the following decisions:

1. Due to the types of expertise in the teams (domain experts versus eLearning designers) we were more interested in distinguishing between the pedagogical content knowledge (PC) and the technological knowledge (T), than to distinguish between the pedagogical (P) and the content (C) knowledge. Thus, we reduced dimensionality of TPCK and considered: (a) P, C and PC as one broad category (PC); and (b) TP, TC and TPC as a second broad category (TPC).
2. Since most of the *seeking* and *sharing* of ideas were in terms of *pedagogical content* (PC) knowledge or *technological* (T) knowledge, and most of the *suggesting* were of design ideas that seemed to have taken all three aspects (*technological*, *pedagogical* and *content* – TPC) into account, our refined coding scheme included only the cells checked in Table 1.

Table 1: Categories used for coding.

	Seek	Share	Suggest
T	✓	✓	
PC	✓	✓	
TPC			✓

With these decisions, we were able to reduce the number of categories to ten (the five categories described in Table 1, times the two types of contributors: Domain and eLearning experts). Table 2 presents examples of utterances coded using these categories. To increase reliability of our analysis, the coding was performed individually by two of the authors of this paper. An eighty-four percent of agreement was reached prior to negotiation on the coding.

Table 2: Coding scheme and examples.

Category	Example Utterance
Seeking pedagogical content (PC) knowledge	<i>Just for the purpose of – because I'm still a novice in terms of my understanding of the purpose of the clinical log books, can you just give us a brief? ... What's the main purpose of the log book to date? How might that change under new curriculum agendas? What's the 'must dos' – what's the bottom line?</i> (A domain expert seeking PC knowledge from another domain expert in the Nursing team)
Sharing pedagogical content (PC) knowledge	[going through a printed document] <i>So this is the overall set of Learning Goals or Learning Expectations ... These are the things that we know that they've learnt about prior to starting their first placement. Then they go on their first placement. And then these are the things that we know that they've then got under their belt before they start their second placement...</i> (A domain expert sharing PC knowledge with an eLearning design expert in the Social Work team)
Seeking technological (T) knowledge	<i>Is it possible to set it up with Twitter and then if it becomes overwhelming I could wave the white flag and you could help me take it down and just replace it with an email address?</i> (A domain expert seeking T knowledge from eLearning expert in the Health Science team)
Sharing technological (T) knowledge	<i>You can do that [refers to question regarding the possibility of the technology used to 'stamp' components of the learning environment called 'assets' with date and time]. Almost every asset has something that you can put a date, time, thing on it. You can also put how long students need to do it.</i> (A technology expert sharing T knowledge in the Nursing team)
Suggesting design (TPC) ideas	<i>If you want to get them [the students] start working on a reflective journal and there's a reflection journal tool in Peddle Pad, then I would start them in Peddle Pad because that's what they're going to continue with, yeah - and part of their portfolio. But also it will give them some clues about their strengths and what they want to develop in field ed. ... We could also add a component of that for professional practice so that across this first semester of the year, they're doing a reflective journal that's integrating a whole lot of learning that's going on this semester.</i> (A domain expert suggesting TPC design idea in the Social Work team)

Findings

Our analysis revealed four unique characteristics of the collaborative design process in each of the three teams:

1. *Multi-dimensional exploration.* Team-members did not attempt to provide solutions before they had a good understanding of the pedagogical-content and technological challenges they were faced with, as exemplified in Figure-1. The figure represents the collaborative design process that took place in one of the Nursing team meetings. The horizontal axis shows a timeline of about one hour, each tick showing one saying of a team-member. The vertical axis represents accumulation of T, PC and TPC knowledge. Each utterance representing T, PC or TPC knowledge, is counted as one knowledge unit. The gradual rise of the three lines in Figure 1 indicates how the progression of design ideas was intertwined with T and PC knowledge sharing.
2. *Balanced process.* Design decisions were made in a balanced process in which both academic team members and eLearning designers were equally involved. This is exemplified in Figure-2 by the interchange of red and blue light-bulb icons, representing design ideas suggested by academics and eLearning designers.
3. *Mutual respect.* Team-members appreciated each other's expertise and used the team-meetings to learn from their colleagues about aspects of the design challenge they were not aware of. This was evident in many instances in which participants sought knowledge either in their own domain of expertise or in the others' domain (e.g., see the question-marks in Figure 2 representing seeking of knowledge by both academics and eLearning designers).

4. *Crossing domain expertise.* In some instances, participants crossed their domain of expertise, and carefully provided ideas that were not in their own domain. This was usually followed by feedback from a domain expert, and was a productive way to move the discussion forward. (e.g., see red exclamation marks on the blue line representing academic team-members sharing technological knowledge, and blue exclamation marks on the red line representing opposite epistemic agency).

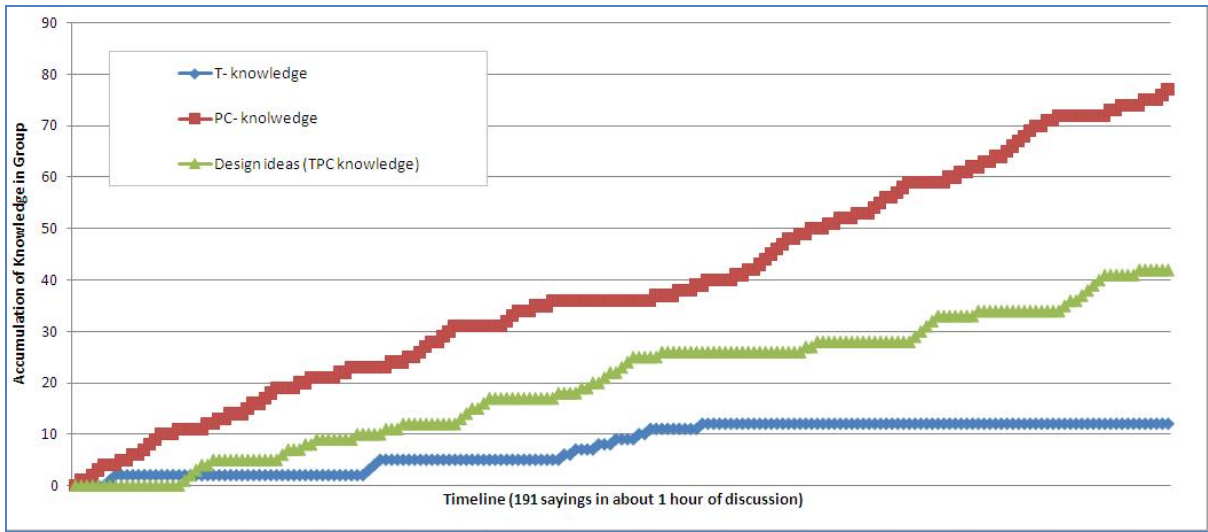


Figure 1. Example of a knowledge-building process in which design ideas gradually develop while one team (Nursing team) explores the pedagogical, content and technological aspects of the eLearning design challenge.

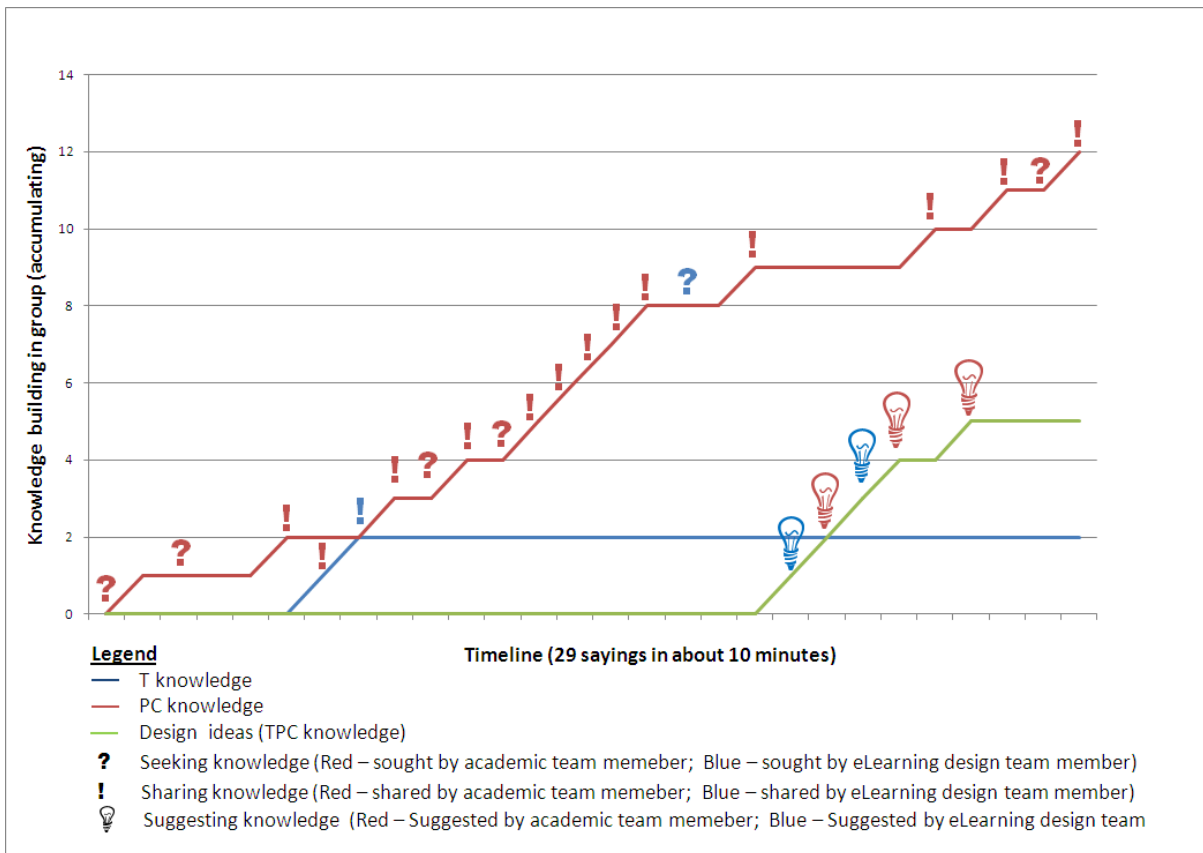


Figure 2. An example of epistemic agency and knowledge-building processes in about 10 minutes of a team discussion (Social Work team).

Discussion and Conclusion

Despite the challenges described in the literature regarding collaborative design, the three teams that we observed were highly successful in designing solutions collaboratively that were based on different epistemic moves and a growing body of the domain (PC) and technological (T) knowledge within the group, which was pretty equally contributed by the academics and the eLearning designers. The question is why? What was there in the specific settings of these three groups that enabled them to succeed so well where others have failed?

One possible answer is the thought-through process of the university eLearning design initiative which these teams were part of (Ward et al., 2010). We see at least two aspects of this process, which might have contributed to the mutual epistemic sensitivity and respect that academics and eLearning designers had to each other's expertise. First, the eLearning designers in the university initiative are carefully chosen to have a significant pedagogical background. Second, the projects are chosen via an extended application and planning period, in which expert committees help to articulate and prioritize projects. In this way only academic teams that have a good sense of the affordances of technology to support pedagogy are chosen. These two aspects of the management process probably helped minimize epistemic and cultural distances, allowed to see fusion points and enabled the mutual respect that we found in our analysis.

Another possible answer has to do with the technological tool used for developing the online courses in the current study. An important aspect of the tool is that it enables non-programmers to develop sophisticated eLearning environments. Such tools are becoming more and more abundant in universities and schools, and require less technological expertise than older generation tools. The result is that pedagogical experts nowadays do not have to be in an inferior position, as described by diSessa et al., (2004), in the collaboration with technologists. If that is the case, and gaps between pedagogical and technological experts are about to diminish, we can expect to find more and more multi-disciplinary eLearning design collaborations, not only between experts, as in the case of the current research, but also among pedagogical and technological practitioners in schools, and other work areas. The four characteristics found in the current research, i.e. *multi-dimensional exploration*, *balanced process*, *mutual respect*, and *crossing domain expertise*, can serve as principles for guiding such collaborative design endeavors.

Finally, we would like to note that combining the TPCK and the shared epistemic agency frameworks helped shed light on the complex process of collaborative design of technology-enhanced learning in the current study. We see a great potential in this combined framework and recommend continuing to explore its use.

References

- Bell, P., Hoadley, C., & Linn, M. C. (2004). Design-based research in education. In M. C. Linn, E. A. Davis & P. Bell (Eds.), *Internet environments for science education* (pp. 73-88). Mahwah, NJ: Lawrence Erlbaum Associates.
- Damsa, C.I., Kirschner, P.A., Andriessen, J.E.B., Erkens, G. & Sins, P.H.M. (2010). Shared epistemic agency: An empirical study of an emergent construct. *Journal of the Learning Sciences*, 19(2), 143–186.
- diSessa, A.A., Azevedo, F.S. & Parnafes, O. (2004). Issues in component computing: A synthetic review. *Interactive Learning Environments*, 12, 109-159.
- Goldman, S., DiGiano, C., & Chorost, M. (2009). Introduction: Preparing the next generation of learning technology designers. In C. DiGiano, S. Goldman & M. Chorost (Eds.), *Educating learning technology designers: Guiding and inspiring creators of innovative educational tools* (pp. 1-18). N.Y.: Routledge.
- Markauskaite, L., Bachfischer, A., Goodyear, P., & Kali, Y., (in press). Beyond technology, pedagogy and content: Insights into the knowledge bases for collaborative eLearning design. Paper accepted for presentation at the American Educational Research Association conference, 2011.
- Mercier, M., Goldman, S., Booker, A. (2009). Focusing on process: Evidence and ideas to promote learning through the collaborative design process. In C. DiGiano, S. Goldman & M. Chorost (Eds.), *Educating learning technology designers: Guiding and inspiring creators of innovative educational tools* (pp. 36-61). N.Y.: Routledge.
- Mishra, P. & Koehler, M.J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1–22.
- Ward, M-H, West, S., Atkinson, S. & Peat, M. (2010). Making it real: Project managing strategic e-learning development processes in a large, campus-based university. *Journal of Distance Education*, 24(1)21–42.
- Winters, N., Mor, Y. & Pratt, D. (2010). The distributed developmental network - d2n: A social configuration to support design pattern generation, in P. Goodyear & S. Retalis, (Eds.), *Technology-enhanced learning: Design patterns and pattern languages*, (pp. 233-254). Sense Publishers, Rotterdam.

Towards a Model for Rapid Collaborative Knowledge Improvement in Classroom Language Learning

Yun Wen, Chee-Kit Looi, Wenli Chen, Learning Sciences Lab, National Institute of Education,
Nanyang Technological University, 1 Nanyang Walk, Singapore 637616
Email: yun.wen@nie.edu.sg, cheekit.looi@nie.edu.sg, wenli.chen@nie.edu.sg

Abstract: The concept of Rapid Collaborative Knowledge Improvement (RCKI) refers to quick cycles of knowledge improvement in the short duration of a classroom lesson. We explore the role of RCKI in language learning in our school-based design research by working with teachers to co-design and enact lessons in classrooms. We design a model, called the *Funnel Model*, to provide a scaffolding structure to enable RCKI practices in the context of reading comprehension. Starting with a stage of individual brainstorming, the model leads to stages of intra-group and inter-group knowledge improvement. The design and implementation of three cycles of RCKI activities in GroupScribbles (GS) supported classroom environment are provided to illuminate the flexibility and diverse uses of the model.

Introduction

Rapid Collaborative Knowledge Improvement (RCKI) refers to the notion of democratizing participation and idea refinement in the context of live dynamic classroom settings, that is, face-to-face collaborative knowledge construction and improvement over the duration of a class session, and supported by certain technologies for lightweight instant interaction (Looi, Chen, & Patton, 2010). When enacted in the classroom, RCKI takes the form of alternative ways to promote classroom interactions that enable students to co-construct knowledge and learn content skills. It is designed to address the constraints faced by classroom teachers when they are designing and implementing knowledge construction and improvement practices within the short duration of a classroom lesson ranging from say half an hour to one and a half hours. The notion of “rapid” is understood from 3 main aspects of a learning activity: 1) it is done within a limited time of participation; 2) it uses a lightweight form of expression; 3) it must enable the participants to have quick cycles of interaction. RCKI focuses on democratic knowledge sharing as well as cycles of individual and group knowledge enhancement. Like the Knowledge Building (KB) process of Scardamalia and Bereiter (1996), it seeks to initiate students into a knowledge creating culture (Scardamalia & Bereiter, 2006). Yet having quick cycles of knowledge construction distinguishes it from KB which connotes the process of idea improvement over a protracted or extended period of time.

In our work, we have explored the use of RCKI in second language (L2) learning classrooms (specifically the Chinese language). The concept of RCKI seems suitable for guiding language learning, especially L2 learning. L2 teachers typically handle the low proficiency of students in the target language by focusing primarily on vocabulary and grammar, and hence approaches like ideas generation and expression are seldom brought to the fore (Scott, 1996; Stapa & Majid, 2009). When cognitive load is not just expended on language expression, the enthusiasm and capacity of L2 learners to engage in reading and writing in on-line based interaction could be enhanced (Wen, Chen, & Looi, 2010). Rather than being interpreted as internal mental process solely by the individuals, the process of L2 is viewed as a semiotic process attributable to participation in social activities (Block, 2003; Lantolf, 2000; Lantolf & Thorne, 2006). Interaction, which has long been considered important in language learning, is not just a device that facilitates learners’ movement along the reconstructing continuum, but a social event which helps learners participate in their own development, including shaping the path it follows (Ellis, 1999). The paradigm shift in language learning from traditional psycholinguistic perspective to sociocultural perspective is a prerequisite for success of RCKI in L2 learning.

Besides, in exploring L2 learning, we have to go beyond classic instructional design approaches in which the learning content is rather systematically determined and pre-structured, and the learner activity is predefined to follow specific, uniform sequences (Lakkala, 2007). It is argued that collaborative practices, or its related learning practices that are underpinned by the socio-cultural paradigm, cannot (should not) be fully designed in advance, as the processes and outcomes emerging in a collaborative learning setting are (and should be) strongly shaped by the joint activity and interaction of the participants themselves (Lakkala, 2007). However, this does not mean totally free, unguided or instructed collaboration can guarantee productive activity or learning (Kreijns, Kischner & Jochems, 2003). In these years, there is a growing amount of research on exploring some form of additional structuring to facilitate collaborative learning and interaction (Dillenbourg & Fisher, 2007). The best known is the notion of collaborative scripts that is proposed by Dillenbourg (2002, 2004) as a compromise between the constraints of classic instructional design and the flexibility needed in collaborative learning. Instead of providing scripting, we propose a collaboration model as a general visual

scaffold for RCKI. We hope it can provide an intuitive grasp of RCKI for teacher facilitators and student learners, especially for beginners. The model is called *Funnel Model* which makes tangible the stages of knowledge improvement. In this paper, the funnel model for realizing RCKI is discussed in the context of Chinese as L2 learning. Three cycles of activity design centred on the theme of reading comprehension were designed and implemented over three weeks. We hope that this practical example can illuminate the flexibility and diverse uses of the model for language teaching and learning in a classroom setting.

What Funnel Model Entails

Instead of collaboration scripts that generally provide a detailed set of guidelines, rules and structured tools for describing how the group members should interact, we attempt to make use of a concrete model constrain the interaction processes so that RCKI can happen. We coin it as “Funnel Model” from its structural conical shape (See Fig.1). Underlying the concept of RCKI, the funnel model provides a tangible structure for one operational collaborative activity design beginning with brainstorming and a structured process of consistent knowledge improvement. The design entails 3 stages: from the wide to the narrow: “*brainstorm*”, “*rise above*”, and “*advance*”. By respecting and encouraging cognitive diversity, the first stage encourages the creation of diverse ideas. The subsequent stages tap on this diversity to seek synergy of ideas, and a stage of convergence and consensus seeking leading to knowledge convergence (Fisher & Mandl, 2005) and advancement.

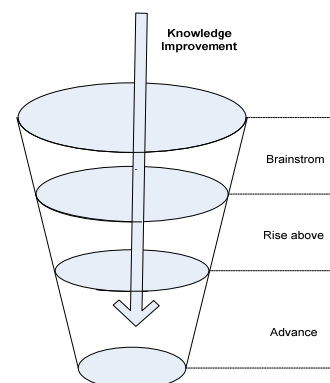


Figure 1. Funnel Model.

GroupScribbles as a Technology for RCKI

In the work reported here, we implemented the funnel model using a collaborative software called GroupScribbles (GS). GS is a software platform designed for supporting generalized coordination among students and the instructor, and it enhances the affordances of sticky paper notes by providing a digital version of it while avoiding some of their physical constraints (DiGiano, Tatar, & Kireyev, 2006). Its specific affordances could enable RCKI practices in a succinct way.



Figure 2. A screenshot of the public board (upper) and private board (bottom).

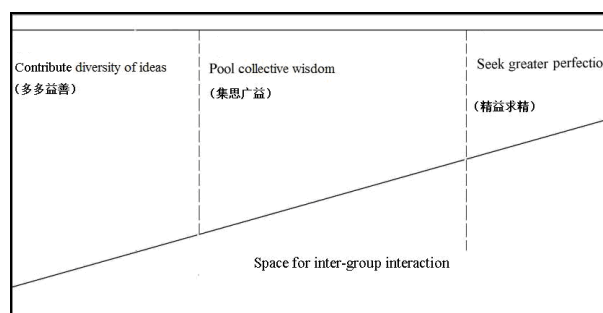


Figure 3. A funnel model template for supporting GS-based activity on reading comprehension.

Figure 2 displays the user interface of GS with a two-paned window. The lower pane is the user's personal work area, or “private board”, with a virtual pad of fresh “scribble sheets” on which the user can draw or type. Scribble sheets are the digital equivalent of small sticky notes that enable a “lightweight” scribbling to be made on the note. Once a student completes a note and moves it into the group boards or “public board”, other students in the same public board can see the posting simultaneously. A student can select any group board by clicking the board number on the right-top, and browse all other groups’ postings on their individual public board. GS hence promotes and facilitates both intra-group and inter-group interactions.

Figure 3 shows a template representing the funnel model to facilitate GS-based reading comprehension. A group board of GS is divided into 4 major areas by the template, of which the main body is consisted by 3 parts. From the left to the right, “*Contribute diversity of ideas*”, “*Pool collective wisdom*”, “*Seek greater perfection*” are the stages as advocated by the funnel model. The bottom space is made available for inter-group interaction, where the students from other groups are encouraged to provide their feedback after visiting this group board.

Experience with the Funnel Model

The design of the funnel model lessons and their enactment is in the context of language classes in a secondary school in Singapore. The school provides a technology-rich environment for students. Each student is equipped

with a laptop (Apple Macbook). The teachers with whom we collaborated with in this school have some familiarity with the role of technologies in education. In the work reported here, we collaborated with a Chinese language teacher Ms H. who holds a strong belief that traditional didactical teaching approach of the Chinese language, that is dampening students’ enthusiasm and motivation, is in urgent need of reform.

We first provided training for the teacher to learn how to use GS. We conducted a series of professional development sessions with her in which we introduced the notion of RCKI and some of its design principles (Looi, Chen & Patton, 2010). In doing co-design of the lessons, we realized that the teacher requires strong scaffolding for guiding them to do concrete lesson design and enactment. We also realized that this scaffolding support will also help students to better understand the teacher’s lesson design objectives. As a consequence, the embryo of the funnel model template was conceived when we co-designed Chinese lessons with Ms H.

Figure 4 depicts the process of our research design. The funnel model as a collaboration model embodies some of the design principles of RCKI, and provides a guide to concrete activity design. Based on the model, we have had several cycles of activity design, implementation, evaluation and re-design. From July to September 2010, we completed these 3 cycles of activity design. During this process, a total of 5 GS Chinese lessons around the theme of reading comprehension (each lesson lasting 110 minutes) was conducted. The Chinese language in Singapore is taught as a L2, of which reading comprehension has always been a key focus. Adopting the design research process, lesson activities were re-designed in each new cycle by considering how to address the problems that emerged in the current design. In going through this process, the teacher facilitators and the students developed a better understanding of the abstract concept and principles in RCKI, helping the teacher to iteratively improve her pedagogical innovation.

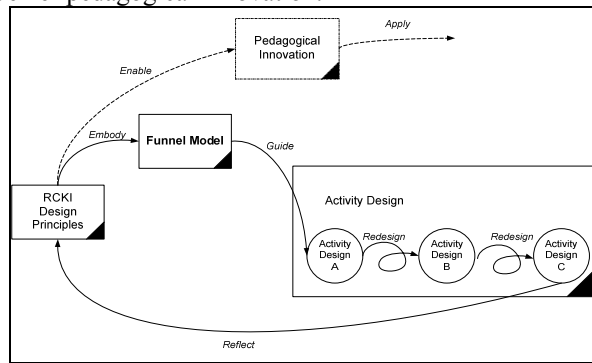


Figure 4. Framework of Our Research Process.

Table 1: Reading comprehension activities designed based on Funnel Model.

Sequences Cycles of activity design	Step 1: Seek diversity of ideas	Step 2: Pool collective wisdom	Step 3: Inter- group visiting	Step 4: Seek greater perfection	Step 5: Group presentation
Cycle 1: Activity A: co- answering questions (lesson 1 & 2)	Brainstorm answers for the guiding questions	Re-organize and synthesize answers via FTF group discussion	Borrow good ideas and provide suggestions for other groups to realize knowledge improvement	Generate own group answers based on comments from other groups	Present own group’s answers in front of the class.
Cycle 2: Activity B: questions generation (lesson 3)	Generate questions and ask themselves whether they can answer these questions	Discuss and select two of the most difficult and valuable questions for challenging another peer group to answer	Visit the peer group’s public board to answer the selected two questions as a group	Judge the peer groups’ answers to the questions, and give their own group’s “perfect” answers.	Explain whether the peer group offer good answers to the questions set by their own group, and give own group’s answers
Cycle 3: Activity C: question- answering (lesson 4 & 5)	Generate questions as many as possible after reading the text	Discuss all of the posted questions, provide the answers to these questions and identify the questions in which they could not reach an agreement within the group	Look through other groups’ questions and answers; help other groups to improve answers for those complex questions	Return to own group space to modify own group answers based on comments given by other groups	Explain what the most difficult questions the group students have posed and how they develop their answers finally.

Table 1 shows the activities that implement the funnel model in our each design cycle. For activity A, the lesson began with the teacher asking the students to read the comprehension essay for that lesson. She then

assigned different comprehension questions for each group of students to address and answer, and those questions were designed to assist students to get to the pith and marrow of the text. After reading the text, the students in each group brainstormed responses to their individual group question. Following the “lightweight” principle, the students were encouraged to contribute their rough ideas or share their prior knowledge in a few words within a short time (usually 5-6 minutes). All the postings in this part were not necessarily very mature, but each new idea was encouraged. Subsequently, the students conducted face-to-face discussions to organize, synthesize and further modify their existing individual postings or create new postings that build on the individual ideas. After that, they were required to visit other group boards, posting their suggestions or comments in the space for inter-group collaboration. When the students returned back to own group board, they were supposed to further refine their group answer based on the feedback given by other groups. After further verbal negotiation and combination, they were required to seek consensus and finalize their group idea, and posted it onto the final stage of the model.

Students in this class of 20 secondary 1 students, taught by Ms H, varied widely in Chinese language proficiency. In all the GS activities, the 20 students were divided into 5 groups. When we collecting data in classroom, two researchers observed each class and took down detailed field observation notes. Screen capturing software iShowU was installed on all students MacBook to capture the process of each student’s work on the PC and their verbal talks and facial expressions. These data can be used to analyze the moment-to-moment students’ interactions in each activity. After each lesson, students were asked to write their comments and feedback concerning the lesson on the class’s blog. When all 4 GS lessons were completed in the term, through interviews, the teacher and the students shared with us their experiences and new understandings of collaborative learning.

Discussion and Conclusion

During the first cycle of designing and implementing activity A, through classroom observations, we identified some problems with the students doing collaborative learning. Two problems emerged: 1) there were not sufficient FTF communication within groups; 2) there was no sufficient awareness of inter-group interaction. These informed out a second cycle and third cycle of activity design, in which activity design B and C were conceived and conducted respectively (Table 1). In the second cycle of design, we strengthened the requirement of inter-group interaction through asking peer groups to set and answer questions for each other. In the third cycle of design, the students were also required to set questions by themselves. Before posting their questions, students should be aware whether they could answer the questions by themselves. They were encouraged to do intra-group FTF communication to solve questions together within the group. As the students were motivated by answering their own queries, there were lots of negotiations among group members. Traditional teaching strategies on reading comprehension were integrated with the funnel model for designing more pedagogical sound activities. Reciprocal teaching, integrated in the design of activity B and activity C as an example, was adopted as a strategy for developing text comprehension. It provided opportunities for students to learn to monitor their own learning and thinking (Palincsar, & Brown, 1984), leading to a greater responsibility for the learning process.

Students’ post-class reflections provide us with some evidence that most of them have a basic understanding of the intention of the funnel model design. Student A wrote that “I like very much the first stage of the model, in which each student can post own ideas, and then we proceed to do analysis and synthesis. It enhances our thinking skills. [我最喜欢各个组员在第一个空格写上想法和构思，我们才会去分析和综合，整个提炼了我们的脑筋的发挥。]”. Student B posted “my favorite is the last part of the activity which requires students to do group discussion. We can learn and help one another through the group discussion. This can help those students who are weak in Chinese. [我最喜欢这活动里的最后部份。因为它需要同学们在小组里讨论。在小组里讨论，能互相学习，互相帮忙。这样能帮助在华文方面比较虚弱的同学。]” It seems that in following the funnel model, students, who have just started how to do collaborative learning, tend to contribute their understanding based on their individual language proficiency and then collaboratively seek an improved group understanding.

The core idea of the funnel model has been internalized by some students. Student A said in the post-interview after all 5 lessons: “*We’re already used to it (the funnel model). Perhaps we will not write it down. But our mind still works the same way. Because we’ve used it a lot of times, we are familiar with how we should think. How to give suggestions and turn them gradually into better answers. We might not use your method. But the idea behind remains the same. From everyone’s ideas to one combined answer.*” The model provides a kind of scaffolding for teachers to embark on collaborative learning activities in the classroom and to monitor the activities to lead towards fruitful collaboration. In our post-interview, Ms H said that she had become more confident of conducting the GS lessons after enacting the funnel model. She added that she had a better understanding of collaborative learning and RCKI: “*We put our ideas 1, 2, 3, 4 together, we must generate a new one. You must have something at the end.*”

The design and enactment of collaborative learning activities in a technologically-enriched classroom is a very complex process that has to take into account a multitude of factors. One way to start is to expose teachers to best practices, either written or as shown on videos. This entails having such best practices to start off with, which is not always the case for new classroom innovations. Adopting a best practice approach also may set up unrealistic expectations for teachers (Bielaczyc, 2006). An approach based on starting from principles is postulated to help teachers to internalize an innovative mindset (Zhang & Scardamalia, 2007). However it is always a challenge for teachers to comprehend such principles especially when they appear to be rather abstract or de-contextualized. A model may be a compromise between the abstract principles and an ideal enactment model that can fully reflect the core of the design may guide the novice participants to make the new concept and technology implementation successful. The funnel model proposed in this article provides one structured representation of the functions and processes to enable RCKI practices. The model is also meant to scaffold teachers to enact and orchestrate the collaborative learning activities in the classroom as well as to build capacity to be able to design such learning activities themselves eventually.

References

- Bielaczyc, K. (2006). Designing social infrastructure-critical issues in creating learning environments with technology. *The Journal of the Learning Sciences* 15 (3): 29.
- Block, D. (2003). *The social turn in second language acquisition*. Washington, DC: Georgetown University Press.
- DiGiano, C., Tatar, D., & Kireyev, K. (2006). Learning from the Post-It: Building collective intelligence through lightweight, flexible technology. In *Proceedings of conference on computer supported cooperative work companion*, Banff.
- Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Inaugural Address, Three Worlds of CSCL. Can We Support CSCL?* (pp. 61-91). Heerlen: Open Universiteit Nederland.
- Dillenbourg, P. (2004). "Split Where Interaction Should Happen", a model for designing CSCL scripts. In P. Gerjets, P. A. Kirschner, J. Elen & R. Joiner (Eds.), *Instructional design for effective and enjoyable computer-supported learning*. Tuebingen: Knowledge Media Research Center.
- Dillenbourg, P., & Fischer, F. (2007). Computer-supported collaborative learning: The basics. *Zeitschrift für Berufs- und wirtschaftspädagogik*. 21, 111-130.
- Ellis, R. (1999). Theoretical perspectives on interaction and language learning. In R. Ellis (Ed.) *Learning a second language through interaction* (pp. 3-33). USA, Philadelphia PA: John Benjamins B.V.
- Fischer, F., & Mandl, H. (2005). Knowledge convergence in computer-supported collaborative learning: *The role of external representation tools*. *The Journal of the Learning Sciences*, 14(3), 405-441.
- Kreijns, K., Kirschner, P.A. & Jochems, W. (2003). Identifying the pitfalls of social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior*, 19 (3), 335-353.
- Lakkala, M. (2007). The pedagogical design of technology enhanced collaborative learning. A position paper for the framework for e-learning Contents Evaluation Project. Retrieved February 2010, from <http://www.elearningeuropa.info/files/media/media13028.pdf>
- Lantolf, J. (2000). Introducing sociocultural theory. In J. Lantolf (Ed.), *Sociocultural Theory and Second Language Acquisition*, Chapter 1 (pp. 1-26). Oxford: Oxford University
- Lantolf, J. P., & Thorne, S. L. (2006). *Sociocultural theory and the genesis of second language development*. Oxford: Oxford University Press.
- Looi, C.-K., Chen, W., & Patton, C. (2010). Principles and enactment of rapid collaborative knowledge building in classrooms. *Educational Technology Magazine*, September.
- Palincsar, A. S. & Brown, A. (1984). Reciprocal teaching of comprehension-fostering and comprehension monitoring activities. *Cognition and Instruction*, 1(2), 117-175.
- Scott, V.M. (1996). *Rethinking Foreign Language Writing*. Boston: Heinle & Heinle.
- Scardamalia, M., & Bereiter, C. (1996). Computer support for knowledge-building communities. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 249-268). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning science* (pp. 97-118): New York: Cambridge University press.
- Stapa, S. H., & Majid, A. H. A. (2009). The use of first language in developing ideas in second language writing. *European Journal of Social Sciences*, 7(4), 41-48.
- Wen, Y. Chen, W., & Looi C.K. (2010). "Ideas First" in Collaborative Second Language (L2) Writing: An Exploratory Study. In Gomez, K., Lyons, L., & Radinsky, J. (Eds.) *Learning in the Disciplines: Proceedings of the 9th International Conference in Learning Sciences (ICLS 2010)* (pp. 436-443). International Society of Learning Sciences: Chicago IL.
- Zhang, J., & Scardamalia, M. (2007). Sustaining principle-based knowledge building innovation. Paper presented at the American Educational Research Association (AERA) Conference, Chicago, IL.

Tabletops for Collaborative Learning: A Case Study on Geometry Learning at the Primary School

Gustavo Salvador-Herranz, Escuela Superior de Enseñanzas Técnicas, Universidad CEU Cardenal Herrera, Avda. Seminario s/n, 46113 Moncada, Spain, gsalva@uch.ceu.es

David Pérez-López, Mario Ortega, Mariano Alcañiz, Manuel Contero, Instituto Interuniversitario de Investigación en Bioingeniería y Tecnología Orientada al Ser Humano, Universidad Politécnica de Valencia, Camino de Vera s/n, 46022 Valencia, Spain,

Email: dapelo@labhuman.i3bh.es, mortega@labhuman.i3bh.es, malcaniz@labhuman.i3bh.es, mcontero@labdesign.i3bh.es

Abstract: The use of learning systems based on tabletops, favors the paradigm of teaching based on constructivism, and appears as a powerful tool for collaborative learning. This article presents the preliminary results of using a tabletop as a learning tool for basic Geometry contents. Study participants were fifth of primary school pupils that were arranged on two groups: one of them used the tabletop as a learning tool and the other one followed the regular course activities. Results show a significant improvement comparing the tabletop based learning group and the regular one. Students working with the tabletop showed high interest and motivation, and a very rich collaborative interaction.

Introduction

Augmented reality (AR) and new HCI technologies like multi-touch surfaces, tangible and sketch based interfaces, appear as promising tools to improve students' motivation and interest, develop cognitive abilities and support the learning and teaching process in educational contexts. True learning is experiential. The more senses are involved (sound, sight, touch, emotions, etc.), the more powerful will be the learning experience. Current development in HCI technology opens the opportunity of creating real user centered applications that promote collaboration an interaction between students and teachers.

This paper presents the preliminary results of using a tabletop developed at our research institute, to support learning activities. The tabletop is able to recognize multiple fingers from different hands and augmented reality marks, and supports educational applications developed on Adobe Flash. This system has been used to conduct a quasi experimental study about a thematic unit on geometric bodies for fifth of primary school pupils. Results show a significant better performance of the group using the tabletop with respect to the group following the regular teaching method.

Related Work

Several studies (Slavin, 1980; Watson, 1991) suggest that teamwork is beneficial for learning. When students work sitting around a traditional table, the space between them is used for communication. In that context, look, gestures and nonverbal behaviors are important elements. Participants can see each other and communication is shared with objects and matter under discussion. However, when students work in teams but in front of a computer, their focus is on the screen space (Piper, O'Brien, Morris, & Winograd, 2006), significantly reducing the communication possibilities, leading to a cooperative model of teamwork. Tabletop systems provide a big interactive surface, suitable to gather around it to multiple users that can interact with the information collaboratively. Hence the new interfaces based on tabletops are a good solution (Harris et al., 2009) as a teaching tool, from the point of view of favoring a true collaborative environment, and promoting learning based on constructivism.

Another type of works focuses on the advantages of using tangible elements to enhance collaborative work. Resnick et al. (1998) present an excellent work in defending children's learning based on "manipulative interfaces". Johann Heinrich Pestalozzi (1746-1827) asserted that students need to learn through their senses and through physical activity, arguing for "things before words, concrete before abstract". O'Malley and Stanton-Fraser (2004) discuss how this type of interaction is helpful in learning tasks, providing students with a kind of tools that encourage collaboration. Pontual and Price (2009) provide an example with good results, using a tabletop with tangible elements. Ishii and Ullmer (1997) and Ishii (2007) propose the use of tangibles as a tool to improve interaction by making it more natural and closer to interactions that take place in the real world. Moreover, augmented reality (AR) is also used and analyzed in several works as an educational instrument. Woods et al. (2004) show the educational benefits arising from the virtual reality (VR) and augmented reality, particularly improving the interpretation of spatial, temporal and contextual content.

Tabletop System

The tabletop system used in this study was developed by members of our research group (Figure 1). The system comprises a video projector and two cameras that provide stereoscopic view of the interaction surface. It supports both multi-user and multi-touch interaction. At the same time, the system is able to recognize augmented reality markers, that can be used to identify each participant student, providing a method to customize the behavior of the applications according to the learning profile of each student. This hardware configuration allows any type of table as the projection and interaction surface. This is a valuable quality for installation in a classroom. The self-calibration capability of the tabletop provides a robust system that can be moved to any location in the classroom, using several students' tables to create the surface of interaction. Current version of the system also supports markerless interaction, which basically is used for augmenting the content of regular textbooks. The system was adapted to be used by children over 10 years. To verify the correct operation, a first experiment was designed (see Figure 1) in which 20 children tested the tabletop, guided by a usability expert.



Figure 1. Tabletop (First Version) Designed by our Research Team.

Learning Contents

For the study, a series of educational applications about "geometric shapes" were developed for fifth course of primary education (10-year-old children). The applications were developed using Adobe Flash and Action Script programming language. On one hand, a teacher application called "Geometric Shapes Examiner" (Figure 2) was developed, mainly to be used by the teacher to make the explanation using the tabletop. It is a 3D interactive application that allows manipulating and visualizing the different elementary geometric shapes. On the other hand, a set of games (Figures 2 and 3) was developed to practice the concepts explained by the teacher in a fun way, thus ensuring a higher and prolonged in time level of attention. Four applications/games were developed: a relationship game, a classification game, a "memory" game and an action game called "the cannon".

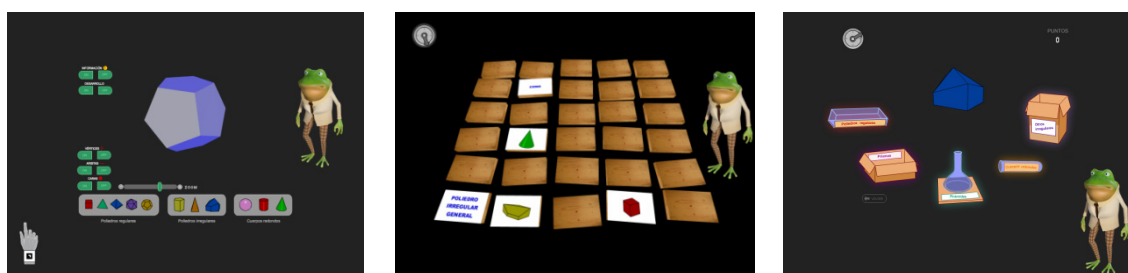


Figure 2. Geometric Shapes Examiner (Left), Memory (Center) and Classification (Right) Games.

Taking into account the observations performed during the usability tests, memory, classification and relationships games were deliberately conceived as turn-based for a single user. Although the tabletop supports multi-user interaction, it was decided to simplify the design of the game and analyze the effect of collaboration between students and competition between groups.

Tangible items were used in the design of the fourth game, called "cannon game", which consists of hitting with a cannonball, a geometric body requested by the system. The cannon is represented by a tangible item, which is simply an AR marker inside a cannon drawing over cardboard. The game is designed to be played by two players. One student handles the cannon and the other is responsible for controlling the power of the shot. Both of them must collaborate to solve the common problem.

One of the main objectives of the research was to design a natural interface that hides the complexity of the technology, and responds to natural movements and actions of the user. Therefore to activate the system, the

teacher simply has to switch on the computer and projector. From that moment, the system is active but projecting a black screen on the table. To launch different applications, students and the teacher have a textbook that incorporates augmented reality markers on its pages. It is enough to open the book on the table by the appropriate page and the system displays a menu next to the book with various applications related to the educational contents shown on the opened page.



Figure 3. General View of the “Cannon Game”.

Evaluation Context

The evaluation was performed on three groups of students in fifth grade of primary school. The first group (group A) consisted of 19 students, 10 boys and 9 girls. The second group (group B) consisted of 19 students, 14 boys and 5 girls. The third group (group C) consisted of 16 students, 9 boys and 7 girls.

There were two different experiences. The first experiment (Experience 1) was developed on the groups "A" and "B" separately. The students studied for the first time the thematic unit "Geometric shapes" using only the tabletop. The objective of this experiment was to test the effectiveness of the system as a unique teaching tool. The second experience (Experience 2) was developed on the "group C" and it consisted of evaluating the result of the utilization of the tabletop in remedial classes. In this case the pupils studied the lesson following the traditional method and were evaluated (pre-evaluation). Later they received two additional lessons of reinforcement using the Tabletop in which the teacher proposed them to play different games. Finally they were evaluated again (post-evaluation). Table 1 and 2 show the planning and development of the experiences.

Table 1: “Experience 1”. Planning and development of the sessions.

Session	Content	Resources	Methodology
1	Introduction to solid geometry	- Geometric shapes examiner	Teacher explains the lesson using the tabletop. The children stand around in groups of 10. The teacher eventually asks questions that children must solve on the tabletop.
2	Regular polyhedra	- Geometric shapes examiner - Memory game (level 1)	Teacher explains the regular polyhedra with the tabletop, and then the children practice individually with the “memory game”.
3	Irregular polyhedra	- Geometric Shapes Examiner - Memory game (lev. 2&3)	Teacher explains the irregular polyhedra and review previous concepts to the children using the tabletop, and then students practice individually with the memory game.
4	Round bodies	- Geometric Shapes Examiner - Memory game (level 4) - Classification activity	Teacher explains the round bodies and review previous concepts to the children using the tabletop and then students practice with the memory and classification activity.
5 and 6	Overlearning exercises	- Memory - Relationships activity - Classification activity - Cannon game	Teacher organizes groups promoting competitiveness, and deciding the order of the games / exercises. Students themselves in a collaborative way try to solve their doubts, helping each other, under the supervision of the teacher.

Table 2: “Experience 2”. Planning and development of the sessions.

Session	Content	Resources	Methodology
1 – 6	Solid geometry	- Traditional method	The teacher teaches by the traditional method.
7 – 8	Solid geometry overlearning	- Geometric shapes examiner - Memory game - Relationships activity - Classification activity - Cannon game	Teacher gives an overview of basic concepts in the "Geometric Shapes Examiner" in the first part of session 7, by actively involving students. Later on, students themselves in a collaborative way try to solve their doubts, helping each other, under the supervision of the teacher.

In both experiments, teachers and students of all groups received a brief training (ten minutes), just before the first contact with the tabletop. Two tabletops were in use for each participating group during each experience, arranging a maximum of 10 children around each tabletop. During the teacher’s explanations, the

students were taking a passive attitude, simply attending to the explanation. On the contrary, during the exercises they were taking a totally active attitude. Most exercises were done individually, by turns, while other students watched and helped the partner if the teacher allowed it. In the exercise developed with the "cannon game", the pupils were playing in couples.

Key Findings

System evaluation was conducted from the point of view of the effectiveness and usability. To evaluate the effectiveness of the system in the "Experience 1", the results (marks in a scale from 0 to 10 points) obtained by the group in a previous learning unit of similar complexity (selected by teachers) were compared to results obtained in the learning unit developed with the tablet. Results for groups "A" and "B" are shown in Figure 4, by means of scatter diagrams, that provide marks obtained by traditional method (previous lesson) and those obtained with the tablet for each participating student (results are better as the slope of the regression line tend to zero). A significant improvement observes in both groups, especially in the pupils that had worse previous marks.

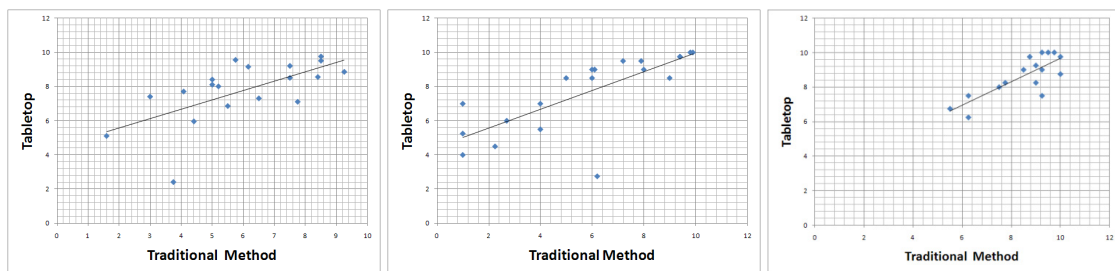


Figure 4. Evaluation of Effectiveness. Groups A (Left), B (Middle) and C (Right).

The experiment carried out at the "Second Experience" (Group C) was designed to evaluate the performance of the system as a tool for reinforcement. Figure 4, group C, shows the scatter diagram that relates marks obtained after studying the thematic unit by the traditional method and marks obtained after the reinforcement sessions with the tablet. It should be noted that in this case it was a group with a high average score, so the results of the evaluation by the traditional method also shows high scores. However there is also an improvement in ratings after receiving reinforcement classes with the tablet, which demonstrates the validity of utilization of the system as a tool for the consolidation of learning.

Table 3: Tool evaluation and development of the class questionnaires.

Tool evaluation	Development of the class
Q1 <i>I prefer the classic book to using the new material</i>	Q6 <i>In this class I have been more attentive than in other classes</i>
Q2 <i>I found it easy to see the geometric shapes with this technology</i>	Q7 <i>This class has seemed to me to be useful and interesting</i>
Q3 <i>I believe that this material will help me to make a better examination</i>	Q8 <i>I would like to take more classes as those of today</i>
Q4 <i>It has been easy to learn to use this material</i>	Q9 <i>It is easier to follow the teacher's explanation in a class of this type</i>
Q5 <i>I would like to use this material at home</i>	Q10 <i>In class today I behaved better than in other classes</i>

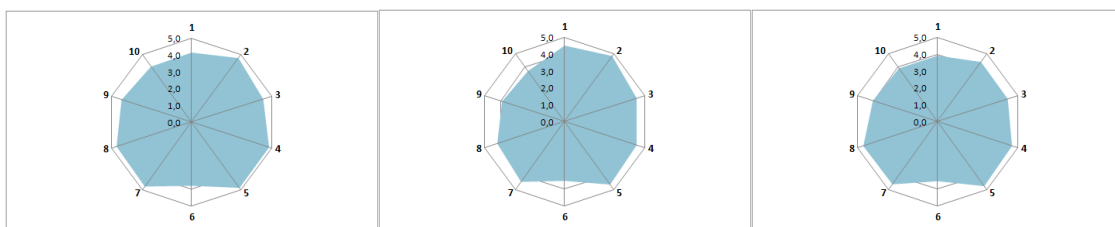


Figure 5. Evaluation of Usability. Groups A (Left), B (Middle) and C (Right).

To evaluate the usability of the system, a questionnaire was developed (Table 3) using a five level Likert scale (1-strongly disagree, 5-strongly agree). The first five questions were devoted to evaluate the tablet as a learning tool and the second five aimed to assess the development of the class with the tablet. First block of questions (Q1-Q5), shows clearly that students prefer the use of the new technology (Q1 is reversed in representation). Although no student had received prior training on the new tool, they think that its

use was simple and transparent, as noted in Q2 and Q4. According to Q3, the majority of students recognize that this tool can help them positively in improving their results, and mostly would like to use these technologies at home too. With respect to the assessment of the development of the class (Q6 – Q10), with this type of technology, students show a greater attention in class, accompanied by a notable interest in the subject being taught and a improved behavior in these classes, compared to the rest of their course.

Conclusions and Future Work

The most impacting element over the experimental work has been the high degree of collaboration between students and self-correction while performing the exercises. During these sessions the teachers were taking a secondary paper and only they were entering in action when it was strictly necessary. An important factor was the introduction of competitiveness in some exercises, increasing notably interest and attention of students. A second element that surprised us was the speed to learn the interaction with the tabletop. Students were faster learners than their own teachers. Here the collaborative action of several students around the table was very important, because of the feedback established between them. The satisfaction and interest showed by the student was very high. The subjective perception by teachers was confirmed by the effectiveness and usability study. The high interest and motivation of the students clearly impacted on their learning performance.

Tabletops provide a big interaction surface that creates an atmosphere of true collaborative work. In this first experience practically we have not taken advantage of all advanced capabilities built into the tabletop system. New experiments are being designed to analyze the effect of the number of students around the table in the global performance of the group. Also, it is expected to analyze the effect over the learning process of the number of simultaneous users in the games. The developed games, presented in this work, can be easily extended to support several simultaneous users. Perhaps more users will mean less interaction with the no playing student looking at the table. In the present experience the single user setup has been a very powerful learning combination.

References

- Harris, A., Rick, J., Bonnett, V., Yuill, N., Fleck, R., Marshall, P., & Rogers, Y. (2009). Around the table: are multiple-touch surfaces better than single-touch for children's collaborative interactions? *In Proceedings of the 9th International Conference on Computer Supported Collaborative Learning (CSCL'09)*, vol. 1, 335–344.
- Ishii, H., & Ullmer, B. (1997). Tangible bits: towards seamless interfaces between people, bits and atoms. *In Proceedings of the SIGCHI conference on Human factors in computing systems (CHI '97)*, 234–241. doi:10.1145/258549.258715
- Ishii, H. (2007). Tangible user interfaces. In A. Sears & J.A. Jacko (Eds.), *The human-computer interaction handbook. Fundamentals, evolving technologies, and emerging applications*, (pp. 469–487). New York, London: Lawrence Erlbaum.
- O'Malley, C., & Stanton-Fraser, D. (2004). Literature review in learning with tangible technologies. Futurelab. http://www.futurelab.org.uk/resources/documents/lit_reviews/Tangible_Review.pdf
- Piper, A.M., O'Brien, E., Morris, M.R. & Winograd, T. (2006). SIDES: A Cooperative Tabletop Computer Game for Social Skills Development. *In Proceedings of 20th Conference on Computer Supported Cooperative Work (CSCW '06)*, 1–10.
- Pontual, T. & Price S. (2009). What have you done! The role of 'interference' in tangible environments for supporting collaborative learning. *In Proceedings of the 9th International Conference on Computer Supported Collaborative Learning (CSCL'09)*, vol. 1, 325–334.
- Resnick, M., Martin, F., Berg, R., Borovoy, R., Colella, V., Kramer K., & Silverman B. (1998). Digital manipulatives: new toys to think with. *In Proceedings of the SIGCHI conference on Human factors in computing systems (CHI '98)*, 281–287. doi:10.1145/274644.274684
- Slavin, R.E. (1980). Cooperative learning. *Review of Educational Research*. 50, 315-342.
- Watson, J. (1991). Cooperative learning and computers: one way to address student differences. *The Computing Teacher*, 18(4), 9–15.
- Woods, E., Billingham, M., Looser, J., Aldridge, G., Brown, D., Garrie, B & Nelles, C. (2004). Augmenting the science centre and museum experience. *In Proceedings of the 2nd International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia (GRAPHITE '04)*, 230–236. doi:10.1145/988834.988873

Acknowledgements

The Spanish Ministry of Science and Innovation (Project ref. TIN2010-21296-C02-01) partially supported this work.

Productive Re-use of CSCL Data and Analytic Tools to Provide a New Perspective on Group Cohesion

Christophe Reffay, STEF, INRP - ENS Cachan - UniverSud, Cachan, France. christophe.reffay@inrp.fr
Christopher Teplovs, University of Toronto, Ontario, Canada. chris.teplovs@utoronto.ca
François-Marie Blondel, STEF, INRP - ENS Cachan - UniverSud, Cachan. francois-marie.blondel@inrp.fr

Abstract: The goals of this paper are twofold: (1) to demonstrate how previously published data can be re-analyzed to gain a new perspective on CSCL dynamics and (2) to propose a new measure of social cohesion that was developed through improvements to existing analytic tools. In this study, we downloaded the Simuligne corpus from the publicly available Mulce repository. We improved the Knowledge Space Visualizer (KSV) to deepen the notion of cohesion by using a dynamic representation of sociograms. The Calico tools have been used and extended to complete this cohesion measure by analyzing lexical markers. These complementary analyses of cohesion, based on clique sizes and communication intensity on the one hand, and lexical markers on the other hand, offer more detailed information on (a) the relationships between participants and (b) the structure and intensity of communication. In particular, the analyses highlight strong convergences that were not visible in the previous analysis.

Introduction

Because of their complexity, authentic learning experiences are hard to replicate. This makes comparison and validation of research tools, methods and results in CSCL difficult. Research collaboration has been well advocated in the context of Technology Enhanced Learning in order to make a greater impact and further elevate our research quality (Chan et al., 2006). This issue has been addressed by various projects that have been concerned with data sharing within communities of researchers.

In the research data sharing perspective, the Dataverse Network project (<http://thedata.org/>) described by King (2007), shows why datasets have to be shared, or at least identified and recorded as persistent, authorized, and verifiable data. For the Intelligent Tutoring Systems (ITS) field, the PSLC DataShop (Koedinger et al., 2010) provides a data repository including data sets and a set of associated visualization and analysis tools in order to evaluate the action/feedback interaction between learners and (virtual) tutor tools. In the CSCL community, the DELFOS framework (Osuna, Dimitriadis, & Martínez, 2001) provides an XML based data structure (Martínez, de la Fuente, & Dimitriadis, 2003) for collaborative actions in order to promote interoperability (between analysis tools), readability (either for human analysts and automated tools) and adaptability to different analyzing perspectives. Some of these authors joined the European research project reported in (Martínez, Harrer, & Barros, 2005) and provide a technical template describing IA tools and a common format.

The Mulce project (<http://mulce.org>) developed a platform (<http://mulce.univ-bpclermont.fr:8080/PlateFormeMulce/>) (Reffay & Betbeder, 2009) to share learning and teaching corpora. This new possibility should deepen our understanding of well-contextualized situations and hopefully better validate tools and have a greater impact on the real world of (collaborative online) learning. Even if more than 30 complex objects are already publicly available on this repository, there is still no evidence of productive re-use of these corpora.

The purposes of this paper are (1) to demonstrate how previously published data can be re-analyzed to gain a new perspective on CSCL dynamics and (2) to propose a new measure of social cohesion that was developed through improvements to existing analytic tools.

Social Network Analysis in CSCL

Social interactions are an inherent aspect of CSCL. Considering participants as a social network (Wellman, 2001) provides a framework that can help us understand what are often complex patterns of interaction. Several studies have used techniques from social network analysis to examine patterns of interaction among CSCL participants (de Laat, Lally, Lipponen, & Simons, 2007; Liao, Li, Wang, Huang, & Zhang, 2007; Martínez, Dimitriadis, Rubia, Gomez, & de la Fuente, 2003; Nurmela, Lehtinen, & Palonen, 1999). They suggest that social network analysis (SNA) can provide useful tools in situations where traditional, statistical methods may not be suitable or may obscure interesting results. Wang and Li (2006) provide a brief history of social network analysis and its application to CSCL.

Among the variety of well established measures like indegree, outdegree, centrality, betweenness, density and cohesion, this paper focuses on the latter. Our cohesion measure is based on the analysis of cliques (i.e. subset of individuals in which all persons are connected to each other), k-cliques (i.e. a clique of k

members) and cliques of level n (i.e. in valued graphs: subset in which all individuals are connected to each other, with an edge which value is at least n).

We were interested in re-examining a data set that had been previously used for a social network analysis. Reffay & Chanier (2003) analyzed the data set described in the next section in terms of cohesion. After providing a description of the data we describe how two existing tools were modified to facilitate the development of a more sophisticated measure of cohesion. This analysis, based on cliques, is also compared with a different method using Calico tools and lexical markers.

The Simuligne Data Re-used

Simuligne is a distance French as a foreign-language learning situation in a trans-disciplinary research project. The global simulation method was generally used for intensive face-to-face language learning courses. In the Simuligne learning situation, it has been adapted to this extensive online learning situation in parallel in 4 basic groups. Everybody worked at a distance; none of the learners had ever met before Simuligne. The participants consisted of 40 learners (English adults in professional training, registered at the Open University, UK), 10 natives (French teacher trainees from the Université de Franche-Comté, Besançon, FR), 4 tutors (teachers of French from the Open University) and one (French) pedagogical coordinator. All agents were dispatched into four basic learning groups, namely: *Aquitania*, *Lugdunensis*, *Narbonensis* and *Gallia*. Each of these groups consisted of 10 learners, two or three natives and one dedicated tutor.

Three groups out of four achieved the simulation, which is a high ratio in distance learning. On May 31st, the *Lugdunensis* group broke up and its two most active learners were transferred to *Aquitania* group. In this study, we focus on the forum exchanges in the four basic groups only for the period before the *Lugdunensis* group broke up, i.e. from April the 3rd to May the 31st.

The Knowledge Space Visualizer

The Knowledge Space Visualizer (KSV) is a software tool (<http://chris.ikit.org/ksv/>) that facilitates the exploration of social and semantic networks in data collected from online discourse environments (Fujita & Teplovs, 2010). In the current study the KSV was modified to allow the representation of social links between authors from the Simuligne data set based on the number of posts that each pair of authors had read (opened) of each other.

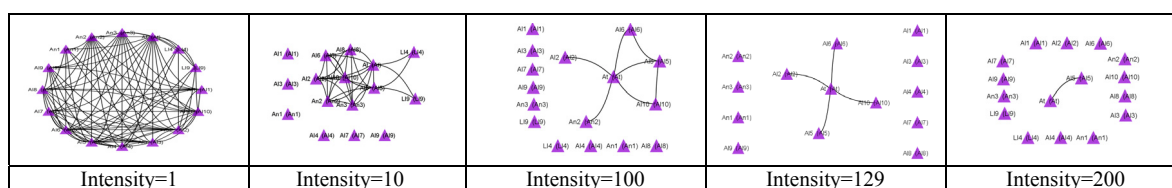
Calico Tools to Analyse Computer Mediated Discussions

The Calico platform (<http://www.crashdump.net/calico/>) was developed for sharing and analyzing discussion forum objects (Giguet *et al.*, 2009). The Calico workspace provides several ways to display the contents of messages, to compute quantitative and qualitative indicators about authors, interactions and topics and to display global or local views on messages and topics (<http://www.stef.ens-cachan.fr/calico/en/tools.htm>). For the purpose of our analysis on specific lexical markers, two Calico tools, namely Colagora and Bobinette, were used to give both general and local measures and views on the utterances of these markers. Colagora displays word occurrences and highlights every matching word in the messages with colors linked to the topics defined by the user. Bobinette is a viewer designed to facilitate reading large forums. It displays messages as circles on a grid with threads in lines and days in columns. Bobinette computes statistics about word topics for each post, thread and day, and highlights messages with the same coding scheme as Colagora.

Social Network Analysis Using an Adapted Version of KSV

The KSV gave us the opportunity to observe the formation of cliques across all the possible interaction intensity values. Considering the graph where nodes represent actors (learners, tutors, natives) and edges communication between actors, KSV draws edges which values are greater than a given intensity threshold and reshapes the graph layout automatically. In Reffay & Chanier (2003), this threshold was fixed and cliques of each group were built with UCINET and compared for this value. The KSV allows us to explore all intensity values for each group and try to find some patterns. This exploration (illustrated on *Aquitania* in table 1) led us to consider the core/periphery model of Borgatti & Everett (1999) and more specifically the Freeman star (Freeman, 1979).

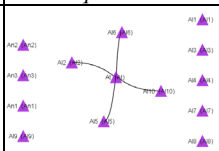
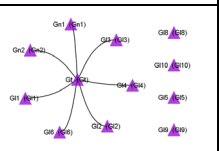
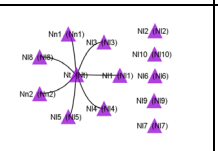
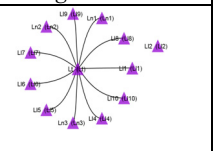
Table 1: Sociograms visualization of *Aquitania* across intensities with KSV for the first 8 weeks of Simuligne.



We were interested in examining the following questions in relation to the appearance of the star structure in response to varying the threshold: What is the intensity value? Who is at the center of the star? Who is a branch of it? Who is not connected?

Table 2 shows the following characteristics: (1) each group shows a single well formed star (with more than 2 branches); (2) among the 4 basic groups, *Gallia* and *Narbonensis* are very similar and *Aquitania* and *Lugdunensis* very different for all values; (3) the center of each group's star is the tutor; and (4) *Aquitania's* star is the only one where no native appear in the star branches. The threshold value is a good indicator of the intensity of the exchanges between members for each group. Extreme values are 12 and 129 respectively from *Lugdunensis* and *Aquitania*.

Table 2: Star shapes and thresholds for 4 basic groups for the first 8 weeks of the Simuligne learning session.

	<i>Aquitania</i>	<i>Gallia</i>	<i>Narbonensis</i>	<i>Lugdunensis</i>
Star shape				
Intensity	129	36	49	12
Nb of branches	4	7	7	11
Who is the center?	Tutor	Tutor	Tutor	Tutor
Who is around?	4 Learners	5 Learners, 2 Natives	5 Learners, 2 Natives	8 Learners, 3 Natives

In Figure 1, we show 4 curves (one for each group). The vertical axis represents the intensity and the horizontal one the maximum size (k) of cliques. The first point of *Aquitania's* curve is (k=3, intensity=128). This means that the highest intensity reached by any 3-clique in *Aquitania* is 128. That is, the communication intensity for any subgroup of 3 members is bounded by 128 messages exchanged by pairs. We can see that the value of the star's threshold (from Table 2) corresponds to the top of the curve for each group on Fig. 1.

In order to get a more precise view of these curves for k-cliques with k>=5, the scale of intensity has been changed from Figure 1a to Figure 1b. We can observe that the intensity of the *Aquitania's* internal kernel (up to 4-cliques) is twice greater than the second one (*Narbonensis*). Up to 7-cliques, *Aquitania* shows the highest intensity. But for bigger cliques (k>7), *Gallia's* intensities dominate the graph. It may be that the very high intensity of exchanges between the core members in *Aquitania* and *Narbonensis* was discouraging the peripheral members. The more modest amount of communication between core members of *Gallia* seems to have kept more members in the core.

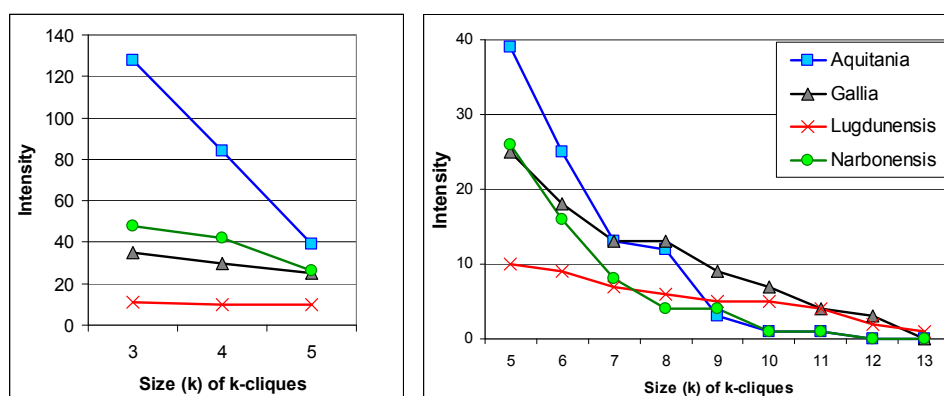


Figure 1a & 1b. Maximum Intensity of Exchange for Each Size of Cliques on the 4 Groups.

Finally, this analysis of cliques for the 4 basic groups shows that (1) *Lugdunensis* cliques (even small ones) have very low intensity values, (2) *Aquitania* and *Narbonensis* have very similar clique characteristics across intensity: a restricted core very active and very little communication exchanged in medium and large cliques. *Gallia's* core (small cliques) shows a lower intensity but this is the group where medium and large cliques have the more intensive exchanges.

The next part analyses the cohesion on the same data, by using lexical markers (provided by Calico). The discussion will show convergences and discrepancies between SNA and lexical analysis of cohesion.

Use of Calico to Analyze Cohesion through Pronoun Markers

In their review of text analysis approaches in the social sciences, Pennebaker, Mehl, & Niederhoffer (2003) discuss the links between several linguistic markers like prepositions, pronouns, emoticons, affective words, and social interaction. Yates (1996) suggests that participants in on-line discussions use first and second pronouns more often than in usual written communication. When examining interactivity in discussion groups, Rafaeli & Sudweeks (1997) found that about 25% of the messages they qualified as “interactive” contain first-person plural pronouns, which is significantly greater than the percentage calculated for the entire corpora of messages (about 10%). Following the same technique, we assumed that pronouns markers may be used as an indicator of group cohesion. For the purpose of this study, we counted the “first-person singular” (FPS), “second-person plural” (SPP) and “first-person plural” (FPP) markers in the 4 basic groups. It should be noticed that in French the second-person plural (“vous”) is different from the second-person singular (“tu”). Figures from the *Lugdunensis* group should be considered with caution because of the low number of messages.

The frequency of the “first person singular” (FPS) markers is very high for all groups, as already observed by Yates (1996) ; from 70% to 81% of messages contains at least one FPS. Except for the *Lugdunensis* group, the three groups have FPP values that are very similar to those found by Rafaeli and Sudweeks. We can assume that the participants of these groups are in a similar situation because they are invited to interact with each other in the same group. The lower percentage of FPP values in *Lugdunensis* can be interpreted as a possible indicator of lower group cohesion (note that the number of messages of this group is also the lowest).

Table 3: Messages and lexical markers in the four basic groups.

	messages	% of messages with FPS (I)	% of messages with SPP (you)	% of messages with FPP (we)
<i>Aquitania</i>	348	77%	30%	24%
<i>Gallia</i>	159	81%	51%	20%
<i>Narbonensis</i>	175	77%	29%	25%
<i>Lugdunensis</i>	73	70%	41%	18%

We also noticed that the use of “second-person plural” markers (SPP) is different among groups and higher in the *Gallia* group. Using Bobinette we explored and visualized which actors and what messages contain the most significant number of markers in different groups. Looking more closely at the number of messages for each actor, we found that the 3 well-functioning groups contained at least 50% of messages posted by learners, in comparison with the only 36% of messages posted by learners in the *Lugdunensis* group. The part of messages posted by natives is more important in *Gallia* (16%) than in *Aquitania* (7%) and *Narbonensis* (5%).

By facilitating the selection of authors, Bobinette shows that tutors from *Aquitania* and *Narbonensis* wrote similarly high numbers of FPP (80) in comparison to the only 23 FPP written by the *Gallia*'s tutor. Furthermore, this abundance of FPP for both of these groups is concentrated in the tutors' messages, 58% for *Aquitania*, 72% for *Narbonensis*, but only 44% for *Gallia*. These results suggest a strong similarity between *Aquitania* and *Narbonensis*, which was not visible in the Reffay & Chanier (2003) analysis.

Discussion

Overall, an important improvement has been made to the earlier cohesion analysis on the Simuligne experiment. Reffay & Chanier (2003) selected a given intensity and drew the cliques only for that value. They suggested the use of hierarchical cluster analysis to find the appropriate intensity value. KSV allows us to examine the entire range of intensity values for clique analysis and it is no longer necessary to choose a fixed intensity value. Instead, we can look for a particular pattern (e.g. a star) and determine the corresponding intensity value.

Two different techniques (SNA and lexical markers) have been used to characterize group cohesion in the same data. These analyses corroborate each other. They both conclude that intensity of exchanges and number of messages are very low for the *Lugdunensis* group to be considered. Lexical analysis shows that the use of “we” is similar in *Aquitania* and *Narbonensis* groups, and both groups also show similar cliques structures across intensity. Besides pronouns, other lexical markers like emoticons, prepositions, and conjunctions could be used with Calico tools to analyze group cohesion.

The Mulce platform facilitated the reuse of the Simuligne corpus to show that comparison of methods and tools on existing data and analysis is possible. Admittedly the process of data reuse and tool modification was somewhat easier than can typically be expected because the data provider worked with the tool developer. Other researchers have found that Simuligne data and context were described with sufficient details to be able to understand them. We demonstrated in this paper that this reuse is productive by bringing more sophisticated indicators and substantial improvements to existing analysis tools (Bobinette and KSV). In this sense, this work opens new perspectives on data reuse in CSCL.

References

- Borgatti, S. P., & Everett, M. G. (1999). Models of core/periphery structures. *Social Networks*, 21, 375-395.
- Chan, T., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., et al. (2006). One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning*, 1(1), 3-29.
- de Laat, M., Lally, V., Lipponen, L., & Simons, R.-J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis. *International Journal of Computer-Supported Collaborative Learning*, 2(1), 87-103.
- Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social Networks*, 1(3), 215-239.
- Fujita, N., & Teplovs, C. (2010). Software-based scaffolding: Supporting the development of knowledge building discourse in online courses. In K. Gomez, L. Lyons & J. Radinsky (Eds.), *Learning in the Disciplines: Proceedings of the 9th International Conference of the Learning Sciences (ICLS 2010) – Volume 1, Full Papers* (pp. 1056-1062). Chicago, IL: International Society of the Learning Sciences.
- Giguet, E., Lucas, N., Blondel, F.-M., & Bruillard, É. (2009). Share and explore discussion forum objects on the Calico website. In A. Dimitracopoulou, C. O'Malley, D. Suthers & P. Reimann (Eds.), *Computer Supported Collaborative Learning Practices: CSCL 09 Community Events Proceedings* (pp. 174-176): International Society of the Learning Sciences.
- King, G. (2007). An Introduction to the Dataverse Network as an Infrastructure for Data Sharing. *Sociological Methods & Research*, 36(2), 173-199.
- Koedinger, K., Baker, R. S. J. d., Cunningham, K., Skogsholm, A., Leber, B., & Stamper, J. (2010). A Data Repository for the EDM community: The PSLC DataShop. In C. Romero, S. Ventura, M. Pechenizkiy & R. S. J. d. Baker (Eds.), *Handbook of Educational Data Mining*. Boca Raton, FL: CRC Press.
- Liao, J., Li, Y., Wang, J., Huang, R., & Zhang, Z. (2007). A systemic model of interaction analysis in CSCL. In V. Uskov (Ed.), *Proceedings of the 10th IASTED International Conference on Computers and Advanced Technology in Education* (pp. 463-469). Anaheim, CA: ACTA Press.
- Martínez, A., de la Fuente, P., & Dimitriadis, Y. (2003). Towards an xml-based representation of collaborative action. In B. Wasson, S. Ludvigsen & U. Hoppe (Eds.), *Designing for change in networked learning environments: Proceedings CSCL'2003*. (pp. 379-383). Bergen, Norway: Kluwer Academic Publishers.
- Martínez, A., Dimitriadis, Y., Rubia, B., Gomez, E., & de la Fuente, P. (2003). Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers & Education*, 41(4), 353-368.
- Martínez, A., Harrer, A., & Barros, B. (2005). *Library of Interaction Analysis Tools. Deliverable D.31.2 of the JEIRP IA (Jointly Executed Integrated Research Project on Interaction Analysis Supporting Teachers & Students' Self-regulation)*. .
- Nurmela, K., Lehtinen, E., & Palonen, T. (1999). Evaluating CSCL log files by social network analysis. . In C. Hoadley & J. Roschelle (Eds.), *CSCL 1999*. Palo Alto, CA: Stanford University.
- Osuna, C., Dimitriadis, Y., & Martínez, A. (2001). Using a Theoretical Framework for the Evaluation of Sequentiability, Reusability and Complexity of Development in CSCL Applications. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *Proceedings of EuroCSCL 2001*. Maastricht, NL.
- Pennebaker, J. W., Mehl, M. R., & Niederhoffer, K. G. (2003). Psychological Aspects of Natural Language Use: Our Words, Our Selves. *Annual Review of Psychology*, 54(1), 547-577.
- Rafaeli, S., & Sudweeks, F. (1996). Networked Interactivity. *Journal of Computer-Mediated Communication*, 2(4).
- Reffay, C., & Betbeder, M.-L. (2009). *Sharing Corpora and Tools to Improve Interaction Analysis*. Proceedings of the 4th European Conference on Technology Enhanced Learning: Learning in the Synergy of Multiple Disciplines. (pp. 196-210).
- Reffay, C., & Chanier, T. (2003). How social network analysis can help to measure cohesion in collaborative distance-learning. In B. Wason, S. Ludvigson & U. Hoppe (Eds.), *Designing for change in networked learning. Proceedings of the international conference on Computer Supported Collaborative Learning 2003*. (pp. 343-352). Bergen, Norway: Kluwer Academic Publishers.
- Wang, Y., & Li, K. (2006). An application of social network analysis in evaluation of CSCL. In R. Mizoguchi, P. Dillenbourg & Z. Zhu (Eds.), *Learning by effective utilization of technologies: Facilitating intercultural understanding*: IOS Press.
- Wellman, B. (2001). Computer networks as social networks. *Science*, 293, 2031-2034.
- Yates, S. J. (1996). Oral and Written Linguistic Aspects of Computer Conferencing: A Corpus Based Study. In S. C. Herring (Ed.), *Computer-Mediated Communication. Linguistic, Social and Cross-Cultural Perspectives* (pp. 29-46). Amsterdam, NL: John Benjamins.

Expert Participation in Elementary Students' Collaborative Design Process

Kaiju Kangas, Pirita Seitamaa-Hakkarainen, Department of Teacher Education, P.O. Box 8,
00014 University of Helsinki, Finland
Email: kaiju.kangas@helsinki.fi, pirita.seitamaa-hakkarainen@helsinki.fi

Abstract: The main goal of the present study was to provide insights into how disciplinary expertise might be infused into Design & Technology classrooms and how authentic processes based on professional design practices might be constructed. We describe elementary students' collaborative lamp designing process, where the leadership was provided by a professional designer. The video-recorded lessons on lamp designing and the *Lamp Designing* view of the project's database constituted the data sources of the study. The results indicate that the designer's participation opened up the world of designing for the students. This enabled the students to engage in embodied design practices, and to gain new insights of the professional mechanisms of designing. Having the professional designer working with them, provided students with the opportunity to gain the full potential that solving complex design problems can offer to learning.

Introduction

This study explores the opportunities afforded by the participation of a professional design expert in elementary students' collaborative design process in context of a broader study project, extending across three semesters. We employ an approach to learning in which design is an integral part of inquiry-oriented knowledge building pedagogy (Fortus et al., 2004; Kolodner et al., 2003; Scardamalia & Bereiter, 2006). Our main goal is to provide insights into how disciplinary expertise might be infused into Design and Technology (D&T) classrooms and how authentic processes based on professional design practices might be constructed. Focusing on the socio-cultural approach, particularly to the research of collaborative learning, we will draw attention to the *participatory learning* and *knowledge-creation* aspects of design learning (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). Participatory learning (Jurow, Hall, & Ma, 2008) means that learning involves external domain experts working with students in the setting to bridge between school practices and community practices.

Design activities provide students important opportunities to work with complex design tasks within authentic and meaningful learning contexts. Design problems are characteristically ill-defined, dynamic, authentic, and complex; they require integration of knowledge across domains, as well as implementation of conceptual ideas in design of materially embodied artifacts (Cross 2004; Murphy & Hennessy, 2001). The characteristics of the cyclical design process and the complex nature design problems also pose some challenges for design-based teaching; we need to understand how to lead and scaffold design based activities. Teachers may not have deep understanding of the embodied nature of designing, and therefore, may not be able to adequately coach design learning. Design-based activity is seen to be an effective means for dealing with the integrated application of disciplinary skills and content (Fortus et al., 2004), but mastering materially embodied aspects of the process requires access to the instruments and practices of professional designers.

Research into cognitive scaffolding (Wood, Bruner, & Ross, 1976) has indicated that, when provided with external, supporting tools, structures, and real-time guidance, students can be helped to succeed in cognitive processes, that are otherwise impossible. Such observations have encouraged investigators to analyze collaborative learning processes, as well as to develop software-based scaffolds (Quintana et al., 2004). Methods that emphasize the apprenticeship approach to learning offer students opportunities to observe, engage in, and create or discover expert practices in context. These methods are based on verbal scaffolding as well as observation of the performance; modes which are also very typical in D&T education.

The non-verbal forms of scaffolding are crucial in D&T contexts. Gestures, such as pointing, and referring to objects/artifacts and tools, support and guide the design process along the verbal scaffolding (Murphy & Hennessy, 2001). When participants of a design process are examined as beings embodied in socio-material worlds, the importance of the non-verbal, manipulative and practical scaffolding becomes apparent. The material aspect of scaffolding is embedded in technological tools, physical artifacts, activity structures, and shared knowledge practices incorporated in learning processes (Pea, 2004). In the context of D&T, the interaction with tools, concrete objects and materials is a central aspect and offers potentially supportive environment for vital collaborative designing i.e., for developing shared objects and understanding (Murphy & Hennessy, 2001). In the design process, the interaction with two- and three-dimensional models (sketches, prototypes) offers students direct possibilities to explore and evaluate a proposed solution's form and function. The design process involves parallel working through conceptual reflection and material implementation.

Consequently, in D&T settings material artifacts and tools have a central role in mediating the learning and scaffolding processes.

The involvement of professionals in education has been recommended in several studies, however, relatively little is known about interactive processes of integrating domain experts in inquiry-oriented classrooms. The central idea of the present study was to describe pedagogical practices that allow one to acknowledge the role of domain expert's participation in design learning. Hence, the following specific research questions were addressed:

- 1) How was disciplinary expertise infused in elementary students' collaborative design process?
- 2) What was the role of social and material scaffolds in implementing the authentic practices of professional designing?

Method

The present study reports an effort to bridge school and professional life by bringing a design expert to the classroom to guide elementary students through a lamp designing process. The lamp designing was a part of a longitudinal study project, "The Artifact Project", where the aim was to break boundaries of traditional schoolwork by fostering students' inquiring and designing with the help of various experts (for detailed description of the project, see Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010).

Participants and the Setting of the Study

The Artifact project was organized in an elementary school, located in a middle-class suburb of Helsinki, Finland. In total, 32 students (19 girls), aged 10–11 years old, participated in the project; out of these, 7 students had linguistic or other educational problems. The focus of the present study, the lamp designing stage, took place in spring 2004 and lasted 11 sessions (one session was 45–135 minutes, depending on the class schedule) during a period of two months. The expert, a professional interior designer specialized in lamp and light designing, was present in the classroom; the interaction between him and the students varied from face-to-face whole-class discussions, to small team conversations, and to sharing of comments through the Knowledge Forum database. The lamp designing process was followed through in 13 teams of 2–4 students, by sketching, drawing, and building prototypes or models. The students also regularly presented their designs to the whole class. The technical infrastructure of the project was provided by Knowledge Forum (KF, Scardamalia & Bereiter, 2006).

Data Collection and Methods of Data Analysis

Our investigation within the Artifact project relies on extensive video recordings of classroom practices. For the present study, we selected all the lamp designing episodes where the designer interacted either with the whole class or with the small teams. In addition, we selected the small-team episodes before and after the interaction with the designer, in order to analyze how the designer's support was taken up by the students. These episodes were further segmented into smaller *design events* ($f=161$), each distinguishable from the others on the basis of the noticeably different content or context (Chi, 1997). The length of the events varied from few minutes to over 15 minutes. One event was a coherent whole, beginning from the point where the designer started interacting with the students, and ending when their interaction was drawn to an end and something else (like peer collaboration) began. For example, the designer's interaction with one team on some particular issue was identified as one design event. Besides the video material, we also analyzed the notes and annotations in the KF "Lamp Designing" view. The analysis on both the video material and the database was performed with some standard procedures of qualitative content analysis (Chi, 1997) with the help of ATLAS/ti software.

The analysis was conducted at four different levels. First, we identified four distinctive social settings in the classroom during the lamp designing process: the designer's presentations, the students' presentations, whole-class discussions, and designing in small teams. Second, the design inquiry phase of the process was determined in accordance to the *Learning by Collaborative Designing* model (LCD, Seitamaa-Hakkarainen et al., 2010): 1) creating the design context, 2) defining the design task and constraints, 3) creating and elaborating design ideas, 4) experimenting and testing design ideas (sketching and prototyping), 5) evaluating design ideas, constraints, and process, and 6) distributing expertise.

Third, we identified the obstacles that the students faced in the various phases of the design process, and fourth, the scaffolding activities (including both social and material scaffolds) that the designer used to support overcoming these obstacles (cf. Quintana et al., 2004). A data-driven approach to categorizing both the obstacles and the scaffolding activities was employed, producing the following six main categories of scaffolding. The designer 1) *provided domain knowledge and own experience* of the design process, and 2) *provided structure for the design tasks*. He also 3) *supported externalization and envisioning of design ideas*, 4) *facilitated idea elaboration*, and 5) *supported professional techniques of external representation*. In addition, the designer 6) *facilitated reflection and evaluation during designing*. Each of these was further segmented into several specific scaffolding strategies, which are presented in table 1. Two independent coders classified

approximately 15% of the designer's scaffolding activities, resulting an inter-rater reliability of .88, which was considered satisfactory.

Results and Discussion

Table 1 provides a general view of the different aspects of the lamp designing process; related to the social setting in the classroom, the design inquiry phase, and the designer's scaffolding activities. The creation of the design context and the definition of the design task took place mainly during the designer's presentations and the whole-class discussions following the presentations. The designer brought his own experience and knowledge of the design process to the classroom, opening up the world of designing for the students. This promoted the collaborative creation of meaningful and authentic design context and task, i.e. the foundations for students' idea generation.

Table 1: Social settings, design inquiry phases, and the designer's scaffolding activities during the lamp designing process.

Social Setting	Design Inquiry Phases	Designer's Scaffolding Activities
Designer's presentations, whole-class discussions	Creating design context	Providing domain knowledge and own experience <ul style="list-style-type: none"> • Making tacit design knowledge accessible • Anchoring information with common experiences
	Defining design task	Providing structure for the design task <ul style="list-style-type: none"> • Focusing attention on the needs for the design • Identifying the design constraints
Designing in small teams	Creating and elaborating design ideas	Supporting the externalization and envisioning of design ideas <ul style="list-style-type: none"> • Providing professional terms for describing ideas • Providing tools and materials for visualizing ideas • Demonstrating how to use sketches and artifacts for visualizing Facilitating idea elaboration <ul style="list-style-type: none"> • Focusing attention on aspects that need elaboration • Providing domain knowledge/language/tools to support elaboration • Modeling alternative solutions
	Experimenting and testing design ideas (sketching and prototyping)	Supporting professional techniques of external representation <ul style="list-style-type: none"> • Guiding to use real measurements while sketching/prototyping • Providing tools/material for sketching/prototyping • Providing hands-on support for handling tools and materials
Students' presentations, whole-class discussions	Evaluating design ideas, process, and product	Facilitating reflection and evaluation during designing <ul style="list-style-type: none"> • Identifying the design knowledge that students may possess • Providing questions and comments that support explicating knowledge • Summarizing central knowledge • Inviting others to evaluate knowledge
	Distributing expertise	

The main activities of the student teams were creating, elaborating, experimenting, and testing design ideas by sketching, drawing, and building prototypes or models. Envisioning the not-yet-existent lamps appeared to be difficult for the students and required both social and physical scaffolding. For example, Ann and Natalie were designing a pendant lamp and had a hard time imagining their lamp from different angles. The designer was busy with other teams and only explained briefly that they have to draw the side view and the cross section of their lamp. The girls did not completely understand these instructions and ended up drawing a picture with a view from more than one angle. Then the designer and the teacher improvised a demonstration with paper cups and the team's drawing (Figure 1).



Figure 1. The Designer and the Teacher Demonstrate How to Visualize a Lamp from Different Angles.

Simple physical scaffolds, such as paper cups and drawings were central to the teams' understanding; the demonstration helped the girls not only to realize the side view of their pendant, but also gain the knowledge of how to envision the lamp from different angles. For expert designers this is basic knowledge, but novices have to learn how it is possible to envision in detail something only imagined, that does not yet exist. Scaffolds helped the students to compensate for the "bootstrapping problem" of mastering rich domain knowledge that they do not yet have; it transformed the tasks and at the same time helped students to build more knowledge for future use (Quintana et al., 2004). The use of material scaffolds revealed the fundamental role of materially embodied processes in design activity.

The students had used Knowledge Forum extensively during previous phases of the project, but it was a new tool for the designer, so it was mainly the teacher who suggested and instructed KF use. She introduced KF's various aspects to the designer, instructed him how to use them, and used shared view (i.e., the teacher's computer screen shared through the data projector) to support participants' reflection. However, KF was in this phase primarily used as a tool for storing and sharing designs, rather than serving as a genuine discursive knowledge building environment. The students mainly wrote notes after face-to-face activities, iterating and saving the ideas already discussed. The teams produced an average of 7 notes (total 93) and the mean note-reading activity was 22,7%, which was considered rather low database activity. The designer wrote four notes and the teacher two. In addition, the designer wrote 16 annotations; the majority ($f=12$, 75%) of them were aimed at helping the students in explicating and sharing their knowledge.

Conclusions

The present investigation reported a longitudinal experiment in which elementary school students appropriated the world of designing under the guidance of a professional designer and the teacher. The aim of the overall project was to engage students in simulating professional practices and building a deeper understanding of the entire design processes, i.e., working with complex design problems, and dealing with different kinds of representations as well as knowledge and constraints related to designing. The development of professional ways of thinking and acting plays an important role in encouraging young people to tackle the creative and technical solutions of the design field. In the present study, the designer's participation opened up the world of designing for the students, helping them to appropriate the basic tools and practices of professional designing. This allowed the students to engage in productive design processes and to gain new insights into the processes and mechanisms of designing. Furthermore, having the professional designer working with the students

provided students with the opportunity to gain the full potential that solving complex design problems can offer; the potential is related to the inherently embodied nature of design learning.

Designing is not mere practical activity for straightforwardly implementing conceptual ideas in practice. For one thing, validation of conceptual knowledge in materially embodied practice makes design a worthwhile cognitive and intellectual experience. The process of iteratively designing and constructing materially embodied artifacts is, in itself, a multi-modal process in which conceptual, practical, and materially embodied activities cross-fertilize and support one another. In the present study, the students were very much working with imagined and envisioned objects, along with actual artifacts. Although the students were guided to utilize various external representations, working with the imagined lamps was very hard for them (cf. Fortus et al., 2004). The various design artifacts that the designer brought into the classroom (e.g., photos, lamps) and the artifacts that the students created in the course of their designing (e.g., sketches, drawings, models) carried the tacit working knowledge of designing, enabling the inexperienced students to pursue genuine design inquiry. The actual implementation of ideas in design of materially embodied but knowledge-laden artifacts offers unique opportunities for learning. Dealing with concrete materials offers probes which evoke novel possibilities of, for example, learning spatial, functional, and aesthetic aspects. More generally, the analysis of the process promises to give a different and valuable perspective on goal directed, embodied and material cognitive activities which aim at a practically adequate outcome.

The shared KF view was actively used as the collective memory of the community throughout the sessions. Through the shared view, both the students' and designer's knowledge was constantly available to viewing by all the participants, promoting collaborative design thinking. Accordingly, the point was not to focus on producing a large number of textual notes to KF database but participate in actual design of materially embodied artifacts. In this regard, KF provided a shared working space that assisted in documenting various aspects of the process and mediating classroom activities in many ways.

References

- Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *Journal of the Learning Sciences*, 6(3), 271–315.
- Cross, N. (2004). Expertise in design: An overview. *Design Studies*, 25(5), 427–441.
- Fortus, D., Dershimer, R. C., Krajcik, J., Marx, R. W., Mamlok-Naaman, R. (2004). Design-based science and student learning. *Journal of Research in Science Teaching*, 41(10), 1081–1110.
- Hakkarainen, K., Palonen, T., Paavola, S. & Lehtinen, E. (2004). *Communities of networked expertise: professional and educational perspectives*. Amsterdam: Elsevier.
- Jurow, S., Hall, R., & Ma, Y. (2008). Expanding the disciplinary expertise of a middle school mathematics classroom: Re-contextualizing student models in conversations with visiting specialists. *Journal of the Learning Sciences*, 17(3), 338–380.
- Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., & Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design into practice. *Journal of the Learning Sciences*, 12(4), 495–547.
- Murphy, P. & Hennessy, S. (2001). Realising the potential – and lost opportunities – for peer collaboration in a D&T setting. *International Journal of Technology and Design Education*, 11, 203–237.
- Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., et al. (2004). A scaffolding design framework for software to support science inquiry. *Journal of the Learning Sciences*, 13(3), 337–386.
- Pea, R. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *Journal of the Learning Sciences*, 13(3), 423–451.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.) *The Cambridge Handbook of the Learning Sciences* (pp. 97–115). Cambridge, MA: Cambridge University Press.
- Seitamaa-Hakkarainen, P., Viilo, M., & Hakkarainen, K. (2010). Learning by collaborative designing: technology-enhanced knowledge practices. *International Journal of Technology and Design Education*, Vol. 20 Issue 2, 109-136
- Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 17, 89–100.

Online Communication and Collaboration in a Community of Practice for Teachers Professional Development

Gyeong Mi Heo, CEFRIO, QC, Canada, gyeongmi.heo@gmail.com
Alain Breuleux, McGill University, QC, Canada, alain.breuleux@mcgill.ca

Abstract: The purposes of this paper are (a) to introduce our BCT (Building Community through Telecollaboration) project that aims to encourage, facilitate and support collaboration among students, teachers and educational leaders to enhance learning across the community in Quebec; (b) to present a conceptual framework forming the basis of our participatory design research approach; and (c) to report our study of teachers' communication and collaboration in this community.

Introduction

The Building Community through Telecollaboration (BCT) project (<http://bctcollaboration.wikispaces.com/>) is a province-wide initiative with educators and administrators from English school boards in Quebec to build an online community of practice (Wenger, 1998) to support collaboration across Quebec for the just-in-time learning of ICT tools to involve students in collaborative projects. The project was initiated in 2007 within a *design research* approach (Bereiter, 2005; Brown, 1992) involving iterative processes of design – evaluation – revision, and close collaboration between teachers, administrators, a University-based research team, and a support team. Since 2009 (Phase 2), we have taken a *participatory design* research approach (Silva & Breuleux, 1994), which emphasizes the engagement of participants in the design process. To that end, we created a Leadership Team formed of the researchers, practitioners, and three lead teachers, who are the leaders of three Cycle groups of teachers. The Cycle lead teachers participated actively in the project development process as representatives of the participating teachers; they also facilitated communication and collaboration among the teachers in their Cycle group. Each group organized various collaborative classroom activities with ICT tools (e.g., WIKI, Blog, VoiceThread, Google Docs, Audacity, and Live Classroom) depending on the needs and the levels of skills of the participating teachers. The significant success of this shift toward a participatory approach and distributed leadership has motivated this report.

In addition, the research presented in this paper is situated within a conceptual and methodological context of innovation and ICT in schools, collaborative technologies, and collegial professional development through learning networks. Our work attempts to create and foster a culture of reflection and sharing among the network of teachers participating in the project to move from individual practice to collaboration, professional engagement, and teacher leadership. A particular focus is for teachers to share their practice through blended online and face-to-face communication. Our participatory design research approach was guided by the following questions: (a) How did the teachers communicate and collaborate in the BCT community?; (b) What are the characteristics of each Cycle group?; and (c) What factors might have influenced the Cycle groups' collaborative activities?

Methods

During the school year 2009-2010, approximately 40 teachers from 18 elementary schools registered in the BCT project. Data were collected from multiple sources:

- a) Discussion transcripts of BCT Discussion Forum;
- b) Sense of community (SoC) questionnaire (Lockhorst & Admiraal, 2009), Computer proficiency (CP), and Classroom use of IT (CU);
- c) Online surveys on using ICT tools;
- d) Needs assessments and Appreciative inquiry at the face-to-face meetings;
- e) Researcher notes on BCT face-to-face meetings and BCT Lead Team meetings (online & offline)
- f) Focus interviews with BCT teachers including the Cycle leaders, administrators, and practitioners.

The data obtained were analyzed by using mixed methods, including quantitative and qualitative approaches.

Findings

For the characteristics of members in each Cycle group, overall, the BCT teachers' levels of CP (3.90 out of 5) and CU (3.68 out of 5) are moderate, and there is a significant relationship between CP and CU. Cycle 3 is the (relatively) higher-competence group in CP and CU while Cycle 1 is the (relatively) lower-competence group in CP and CU. Actually, the majority of Cycle 1 teachers were newcomers to the BCT Project and also novices in ICT in the beginning of the school year. The results of the SoC Questionnaire (4.18 out of 5) reflect that a relatively positive sense of community has developed in their Cycle groups. Interestingly, we see a trend

towards an inverse relationship between the degrees of SoC levels of competencies in CP & CU, suggesting that some teachers who are already competent in CP and CU and able to implement classroom projects with ICT do it by themselves without collaborating with other BCT teachers. Hence, it raises questions as to how the ICT competent teachers can be integrated within the BCT community as well as novice teachers.

The BCT teachers interacted with each other online between the face-to-face meetings. We investigated their usage of the BCT discussion forums and their perceptions of using ICT tools for their online communication and collaboration. For the usage of the discussion forums, each Cycle group showed different interaction patterns. Cycle 3 represented a positive interaction pattern in a more ongoing and interactive way in comparison to those of Cycle 2 which was rather limited. In addition, the Cycle 3 teachers initiated a discussion topic not only on a specific collaborative project but also in relation to teachers' general practice while the Cycle 1 teachers used the discussion forum for sharing information and resources. In addition, each Cycle group's collaborative classroom projects can be found at <http://bctcollaboration.wikispaces.com>.

Overall, ongoing, interactive communication among BCT teachers did not take place as much as we expected. Time constraints were a major concern for teachers in relation to their online activities. BCT teachers prefer using Email to the discussion forum for interaction with other BCT teachers. Since it was the first year that the BCT discussion forum was introduced to the teachers, it is clear that they needed more time and considerable effort to learn how to use this new tool. In sum, online communication and collaboration in the BCT community has increased slowly but positively. BCT teachers have been more comfortable with using the discussion forum and posting messages, now it is time to encourage them to use it in more regular and interactive ways by offering a range of communication and collaboration activities along with clear guidelines and sensible deadlines.

Conclusions and Implications

Based on the findings above, we discuss some issues and suggest strategies for increasing and facilitating teachers' communication and collaboration in the BCT community along with plans for 2010-2011. Our reflection has focused on: a) how to satisfy the diverse needs of teachers with diverse expertise, b) jump starting and scaffolding a culture of sharing and reflection; and c) stimulating a higher level of participation on-line. There is a wide range of expertise across the group of BCT teachers. Hence, we need to consider how we can meet the needs of the many beginning teachers as well as those who are more advanced. The concept of *Cycle Leaders* allows the competent teachers to help/support others, develop their professional practice and knowledge, and contribute to the BCT community. Along with this, another form of relationship between competent teachers and other BCT teachers –namely, a *buddy system*– has been initiated in 2010-2011. As a CoP for teachers, it is crucial to develop shared visions and goals among members of the community –a *joint enterprise*– as well as to set individuals' personal goals. To do that, a *Self-reflection sheet* was developed to help teachers clarify and reflect on their own goals in the BCT project, level of ICT competencies, needs and expectations from the BCT community, and hence build common visions and goals of the BCT community. To encourage teachers' joint engagement, each Cycle group was asked to develop *Group Guidelines* through group consensus. The guidelines are expected to be effective in terms of teachers' self-motivation and self-regulation. In addition, the Leadership Team has made a particular effort in building trust and creating a safe, respectful, and supportive environment in the BCT community.

In sum, we add one more voice to the choral of remarks on how challenging it is to create a culture of sharing online about practice within a group of elementary school teachers. Our results, however, lead us to be optimistic about the potential success of the approach we have taken namely participatory design research. Therefore, this study contributes to advancing our understanding of an innovative educational research approach, namely *the participatory design research*, as well as our knowledge of the conceptual framework in relation to professional development through learning networks. In addition, the findings offer useful practical suggestions for supporting teacher collaboration which can be applied in other teacher communities of practice.

References

- Bereiter, C. (2005). Design research: the way forward. *Education Canada*, 46(1), 16-19.
- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences*, 2(2), 141-178.
- Lockhorst, D., & Admiraal, W. (2009, August). *A descriptive model of teacher communities*. Paper presented at 13th Biennial conference of EARLI (European Association for Research on Learning and Instruction), Amsterdam, the Netherlands.
- Silva, M., & Breuleux, A. (1994). The use of participatory design in the implementation of internet-based collaborative learning activities in K-12 classrooms. *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century*, 2, 99-128.
- Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. NY: Cambridge University Press.

Students Changing their Conceptions of Collaboration through Computer-supported Knowledge Building

Yu-Hui Chang, Huang-Yao Hong, Pei-Chen Tsai, Po-Hsien Wang, National Chengchi University, Taiwan
 Email: lemini212@gmail.com, hyhong@nccu.edu.tw, 98152014@nccu.edu.tw, 96152006@nccu.edu.tw

Abstract. This study explored the effects of knowledge building on fifth-graders' conceptions of collaboration. Data were from (1) notes posted online; and (2) a survey on students' conceptions of collaboration. Findings indicate the experimental class was able (1) to work beyond pre-determined fixed-group structure and engage in unplanned, emerging collaboration, and (2) to develop a more informed view of collaboration—i.e., seeing collaboration both as a means to support learning and to foster knowledge creation.

Learning and knowledge creation are two different kinds of cultural activities (Hong & Sullivan, 2009). Learning is “mainly a process of acquiring desired pieces of knowledge” (Paavola, 2002, p.24) and highlights a psychological concept of knowledge that views knowledge as possessed within an individual's mind (Hyman 1999; Popper 1972). Knowledge creation, however, values the innovative process of inquiry where “something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process” (Paavola, 2002, p.24). Based on this distinction, collaboration can also be divided into two kinds: collaboration to support learning and collaboration for knowledge-creating (Hong, in press). Conventional school culture tends to place more emphasis on collaboration for leaning, whereas in many science or business cultures, collaborative knowledge-creating is a norm. In the study reported, we explored the question of whether it is possible to foster more collaborative knowledge-creating activities in a science class by engaging fifth-graders in knowledge-building and whether doing so would change their conceptions of collaboration.

Method

Participants were two classes of fifth-graders from Taipei, Taiwan. To ensure comparability, both classes (1) were taught by the same science teacher over a semester (18 weeks), (2) were divided into six small groups; (3) had the same instructional goal (learning about greenhouse effect) and shared same learning resources (e.g., library and Internet); and (4) were tested about their conceptions of collaboration. All instructional activities remained the same except that students in the experimental class (n=34) adopted a pedagogical approach called knowledge building. In brief, knowledge building is a social process focused on sustained production and improvement of ideas of value to a community (Scardamalia & Bereiter, 2006) and is supplemented by Knowledge Forum (KF)—an online multimedia knowledge-building environment. In contrast, students in the control class (n=33) employed group-based, Jigsaw learning (Aronson & Patnoe, 1997). Specifically, it was performed by (1) identifying an overall learning task (i.e., understanding greenhouse effect), (2) dividing the whole task into sub-tasks, (3) helping each group to master one sub-task (e.g., what is greenhouse effect and how does it happen), and (4) finally having each group share its knowledge in the whole class like completing a puzzle. Most participants came from families with a lower socioeconomic status. All students have no experience of using Knowledge Forum before. The teacher, although has taught science for more than 10 years, had only one-year experience of using Knowledge Forum in teaching. Data mainly came from: (1) notes recorded in a Knowledge Forum database, and (2) a self-developed survey assessing students' conceptions about collaboration. For analysis, we first looked into online interactions in Knowledge Forum throughout the whole semester. Then, we qualitatively analyzed the survey. The survey contains several open-ended questions about collaboration (e.g., what is collaboration? why is it important? how do you usually do it?). An open-coding procedure (Strauss & Cobin, 1990), using sentence as unit of analysis, was performed based on the two types of collaboration mentioned above (see Table 1). An inter-coder agreement was calculated to be .92.

Results

First, to find out whether and how students in the experimental class collaborated, we first analyzed students' overall online activities in Knowledge Forum. In total, it was found that students created 360 notes (M=10.91, SD=7.38) in Knowledge Forum. There were in general two types of collaborative notes in Knowledge Forum: co-authored and built-on notes. First, among all notes, about one third (33.06%) are co-authored notes, while the rest (66.94%) are individual notes. If we analyze all notes in a different way, then, it was found that more than half of all notes (61.67%) are build-on notes, and only 38.33% are non-build-on notes. To further examine the developing process of online activities, we divided the semester into two stages (stages 1 and 2), using midterm as a separation point. As a result, it was found that the total percentage of the individual notes decreased from 81.77% (Stage 1) to 47.77% (Stage 2) and that of the co-authored notes increased from 18.23% (Stage 1) to

52.23% (Stage 2). Likewise, the total percentage of non-build-on notes decreased from 45.81% (Stage 1) to 28.66% (Stage 2), while that of build-on notes increased from 54.19% (Stage 1) to 71.34% (Stage 2). Moreover, when looking deeply into students' collaborative behaviors in terms of network density, it was found that (1) the density of students' note-reading activities increased from 18.23% (stage 1) to 52.23% (stage 2), and (2) the density of their note-linking activities also increases from 14.76% (stage 1) to 31.26% (stage 2). The above findings suggest a pattern of an increasing collaborative capacity in the experimental class. Second, to find out whether engaging students in knowledge building would also change their conceptions of collaboration, we analyzed the survey questions. As a result, it was found that there is a significant difference between the pre- and post-survey results for the experimental class ($\chi^2=9.56$; $p<.01$) but not for the control class ($\chi^2=1.16$; $p>.05$) (see Table 2). The findings suggest that engaging students in knowledge building activities is helpful for students to develop a more informed view of collaboration, i.e., seeing collaboration not just as a means to support learning but also as a means to foster knowledge creation.

Table 1: Coding scheme for analyzing students' concepts about collaboration.

Category	Feature	Example
Collaboration for learning	Group activities	Everyone works together to complete the task. (B22)
	Acquiring knowledge from others	Asking teachers for answers. (B36)
	Sharing/learning together	Research a topic and study in a place together. (A26)
Collaboration for knowledge creating	Producing ideas	Search for information in the internet to find new ideas. (B35)
	Exchanging ideas	Put our ideas together and do research. (A03)
	Improving ideas	We researched scientific problems together, discussed in Knowledge Forum, and then integrated our ideas. (A11)

Table 2: Students' conceptions about collaboration.

	Conceptions of collaboration	Pre-test	Post-test	X ²
Experimental class	Collaboration for learning	72.73%	52.87%	9.56**
	Collaboration for knowledge creating	27.27%	47.13%	
Control class	Collaboration for learning	72.34%	66.84%	1.16
	Collaboration for knowledge creating	27.66%	33.16%	

* $p<.05$ ** $<.01$

Discussion

Collaborative competence has been recognized as an important 21st-century skill essential for one to succeed in the future society; this is in particular relevant in a knowledge economy where the capacity of collaborative work with new ideas and knowledge for solving pressing societal problems is ever-increasing (Trilling & Hood, 1999). To cultivate such collaborative competence, it is essential to design appropriate CSCL environments that allow students to explore various collaborative practices and to broaden their view of collaboration. As assessed in this study, employing group-based collaborative learning (i.e., the Jigsaw method in the control class) may be limiting, as most collaborative learning activities would only occur within groups. In contrast, knowledge building would allow students to work with emerging ideas beyond groups, hence prompting students to collaborate more intuitively and opportunistically, and helping them to develop a more informed view of collaboration. Further discourse analysis will be conducted to triangulate the initial findings.

References

- Aronson, E., & Patnoe, S. (1997). *The jigsaw classroom*. New York: Longman.
- Hong, H.-Y. (in press). Beyond group collaboration: Facilitating an idea-centered view of collaboration through knowledge building in a science class of fifth-graders. *Asia-Pacific Education Researcher*.
- Hong, H.-Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research & Development*, 57(5), 613-627.
- Hyman, J. (1999). How knowledge works. *The Philosophical Quarterly*, 49(197), 433-451.
- Paavola, S., Lipponen, L., & Hakkarainen, K. (2002). Epistemological foundations for CSCL: A comparison of three models of innovative knowledge communities. In G. Stahl (Ed.), *Computer-supported collaborative learning: Foundations for a CSCL community* (pp. 24-32). Hillsdale, NJ: LEA.
- Popper, K. R. (1972). *Objective knowledge: An evolutionary approach*. London: Oxford Univ. Press.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*. Cambridge: Cambridge Univ. Press.
- Strauss, A. L., & Corbin, J. (1990). *Basics of qualitative research*. Newbury Park, CA: Sage.
- Trilling, B., & Hood, P. (1999). Learning technology and education reform in the knowledge age or "We're wired, webbed and windowed, now what?" *Educational Technology*, 39(3), 5-18.

Location-based Language Learning: Bridging Theory and Practice

Armanda Lewis, New York University, 239 Greene Street, New York, NY 10003, al861@nyu.edu

Abstract: This poster will present the potentials of location-based learning to successfully bridge formal and informal content, enhance the participatory and interdisciplinary aspects of second language acquisition (SLA), and facilitate the cohesion of the theoretical and the practical tenets behind SLA. Present research will also discuss the design and piloting of a location-based language-learning application for smartphones and propose how such a tool can promote collaboration among learners.

Introduction

The most meaningful foreign language experiences occur when students use their linguistic skills in specific, relevant situations, often called contextualized or situational learning. Mobile devices with locative capacities hold potential for language learning to occur in specific social contexts. Specifically, GPS-equipped mobile devices know where they are at a given time and place, and can thus convey time- and place-relevant information to its users. The 2009 Horizon white paper states that location-based learning gives students pertinent content “just-in-time” and turns: “learning-in-an-authentic-context into a personal experience, and [enables learners] to share this experience with others” (3). Smart phones provide Internet access through wireless and 3G networks, locative capacities, in addition to the more traditional SMS and calling abilities. Pedagogically speaking, such devices are suitable for various learning styles and encourage “conversational learning” since they help to create an atmosphere where learners “can converse with each other, by interrogating and sharing their descriptions of the world” (Naismith et al., 2004, p. 2).

There are several “real-world” location-based language learning applications that embody these theories and involve the completion of specific tasks. Such studies utilize RFID technology, semacodes, or computer programs that simulate situational experiences (Huang, Yang, & Hwang, 2010; Ogata & Yano, 2004; Wong & Looi, 2010). I term these context-aware tasks, technology-assisted location-based activities “TALBA”.

Lingualocus: Potentials of Technology-assisted Location-based Activities (TALBA) within Language Learning

One project that contributes to incorporating TALBA into language learning is lingualocus, a multiplatform application designed for the web and smartphone which features user-generated language learning activities associated with place and utilizes GPS. Conceived out of a desire to bring contextualized and collaborative language activities to students as they traverse the city in realistic situations, the application was developed according to four principles that pull from CSCL, situational, and location-based learning theories. The application seeks to: Contain material which relates to the three Ls—specific languages, learning levels, and locations; Provide a meaningful, user-friendly learning experience centered around location through the web and the phone; Be suitable for informal learning environments but incorporate content from formal learning environments; and Promote collaboration, community, and self-directed learning.

The main questions posed at the outset of the project were the following: How can GPS technology create and/or facilitate situational language learning?; What role does location play in encouraging the use of language skills in informal learning environments?; Do place-based encounters promote collaboration and cultural understanding?; and Can a location-based learning tool create community? If so, how? These questions still remain unanswered, but initial findings are encouraging. As part of the prototype phase, lingualocus is currently limited to Spanish, selected language teachers and their students, and locations in New York City. lingualocus takes advantage of the city’s rich cases for language use—opportunities to practice speaking, improve pronunciation and boost vocabulary in specific and relevant situations, such as shopping for groceries, ordering a meal or learning about art,—and provides scaffolding and encouragement for the student.

The system works as following: Selected students register online and enter their language, level, instructor, and interests (ex. food, music, etc.). Teachers register and may create, upload, and manage searchable multimedia activities related to specific places, languages, learning levels, and students. Places are stored in the system as coordinates. Students may access pertinent activities on the web, or they may choose to use the locative feature on their smartphones (currently Android only). The online component functions with the student going to the site and completing an assigned activity or searching for activities. Since the system is aware of the user’s language and level, pertinent activities are suggested, but students can also access activities of varying levels. The locative feature of the application utilizes the phone’s GPS. Users turn on the application and log on. As they go about their day, students will be pinged with activities that match language and levels; activities are ranked depending on user interests. The GPS compares the user’s current location with data stored in the system. When matches are made, the system alerts the user.

In the initial prototyping phase, one intermediate-level high school Spanish class of ten students participated. Five students were in the control group and did not participate in TALBA, but did receive location-based activities, and five students did participate in TALBA. The technology of choice was an Android mobile phone, which allowed for phone-based, web-based, and GPS-based activities. Both groups were exposed to identical in-class assignments and drill exercises related to similar themes and grammar topics. The experimental group had additional technology-assisted activities that required going to specific places in order to complete assigned tasks. Initial outcomes have indicated a qualitatively higher level of enthusiasm, a bridging between the formal and informal learning environments, increased collaboration, and better recall on vocabulary. In addition to indicating improved feedback and content retention, results demonstrate that students receive more opportunities to speak and hear, are more motivated to use difficult grammatical concepts, and are more likely to use these concepts correctly.

Though in a nascent stage, lingualocus holds promise for exposing learners to authentic and situational language use by bringing the experience out of the classroom. Scaffolding and feedback are provided so that students will feel supported but also motivated and emboldened to practice. One ultimate goal of the project is to add a more social element so that learners will form language-based communities spontaneously. Initial findings encourage more experimentation around the notion that adding the element of place to language use will contextualize the act even more, increase the learner's enthusiasm for speaking, and provide opportunities for speaking.

References

- Huang, A.F.M., Yang, S.J.H., & Hwang, G.J. (2010). Situational Language Teaching in Ubiquitous Learning Environments. *Knowledge Management & E-Learning: An International Journal*, 2, 312-327.
- Johnson, L.F., Smith, R., Lomas, C.P., Oblinger, D.G., & Levine, A. (2008). *The 2008 Horizon Report*. Austin, TX: The New Media Consortium / Boulder, CO: The EDUCAUSE Learning Initiative.
- Kadyte, V. (2004). Learning can happen anywhere: A mobile system for language learning. In J. Attewell & C. Savill-Smith (Eds.), *Learning with mobile devices* (pp. 73-78). London: Learning and Skills Development Agency. Retrieved from <http://www.lsd.org.uk/pubs/>
- Naismith, L., Lonsdale P., Vavoula, G., & Sharples, M. (2004). *Literature Review in Mobile Technologies and Learning*. London: Futurelab.
- Norbrook, H. & Scott, P. (2003). Motivation in mobile modern foreign language learning. In J. Attewell, G. Da Bormida, M. Sharples, & C. Savill-Smith (Eds.), *MLEARN 2003: Learning with mobile devices* (pp.50-51). London: Learning and Skills Development Agency. Retrieved from <http://www.lsd.org.uk/files/pdf/1421.pdf>
- Ogata, H. & Yano Y. (2004). CLUE: Computer Supported Ubiquitous Learning Environment for Language Learning, *IPSJ*, 45, 2354-2363.
- Thornton, P. & Houser, C. (2005). Using mobile phones in English education in Japan. *Journal of Computer Assisted Learning*, 21, 217-228. Retrieved from <http://www3.interscience.wiley.com/cgi-bin/fulltext/118652060/PDFSTART>
- Wong, L.-H. and Looi, C.-K. (2010), Vocabulary learning by mobile-assisted authentic content creation & social meaning-making: two case studies. *Journal of Computer Assisted Learning*, 26: 421-433.
- Zhao, Y. (2005). The future of research in technology and second language education. In Y. Zhao (Ed.), *Research in technology and second language learning: Developments and directions* (pp. 445-457). Greenwich, CT: Information Age Publishing, Inc.

Hidden Structures in Asynchronous Course Forums: Toward a Golden Ratio Population Parameter

Paul Gorsky, Open University of Israel, Ra'anana, Israel, paulgo@openu.ac.il

Abstract: Gorsky, Caspi and their colleagues (2010) calculated a bi-modal *population parameter* for the distribution of "teaching presence", "cognitive presence" and "social presence" in asynchronous course forums based on disciplinary differences, group size and academic level. Findings from this study, carried out at a campus-based college, did not support the parameter. However, a ratio was found between social presence versus the sum of cognitive and teaching presence that was constant across the three variables cited above and institution type. This is the Golden Ratio.

Introduction

Gorsky, Caspi and their colleagues (2010) analyzed three week segments from 50 course forums, 25 from the exact sciences and 25 from humanities, at the Open University of Israel using the quantitative content analysis technique derived from the "Community of Inquiry" model (Garrison, Anderson, & Archer, 2000). Findings, shown in Table 1, pointed toward a bi-modal *population parameter* for the distribution of "teaching presence", "cognitive presence" and "social presence" based on disciplinary differences, as well as group size (small, medium, large) and academic level (introductory, regular, advanced). This study attempts to corroborate these findings based on the analysis of an entire asynchronous course transcript from an undergraduate history course forum at a campus-based college.

Methodology, Instruments and Procedure

The forum studied was from the course "The History of War" taught at an academic college in northern Israel. Of the 119 students enrolled in the course, 29 (24.3%) posted at least one message in the forum. Two instruments were used for obtaining data: (1) the course log site that recorded messages, and (2) the quantitative content analysis technique, which was used to analyze and code transcriptions from the forum. This widely used technique is reliable and valid (Garrison & Arbaugh, 2007). In the present study, the message unit was used; coding was at the category level. 188 messages were analyzed; 86 were posted by the instructor (45.74%) and 102 were posted by students (54.26%). 25% of postings were randomly chosen and re-estimated by a second rater; 92% agreement was achieved.

Findings

Table 1 shows findings from this study ("Campus-based college") juxtaposed with the calculated bi-modal population parameters for the humanities and exact science courses derived from the Open University forums.

Table 1: Calculated population parameters and findings from the campus-based college forum.

Forums	Social presence	Teaching presence	Cognitive presence	Totals
Open Univ. (25: exact sciences)	57.64%	18.27%	24.09%	100%
Open Univ. (25: humanities)	65.87%	18.98%	15.15%	100%
Open Univ. (Average)	61.75%	18.63%	19.62%	100%
Campus-based college (1: humanities)	63.72%	31.18%	5.10%	100%

There is a significant difference $\{\chi^2(2) = 24.708, p < .0001\}$ between the campus-based college forum and the calculated population parameter for forums in the humanities. In other words, at best, it appears that the calculated parameter is appropriate only for forums at distance education institutions.

Given, however, similar rates of social presence, further analysis was carried out with coding based on social presence versus the sum of teaching and cognitive presence. Results are shown in Table 2.

Table 2: Distributions for social presence *versus* the sum of teaching and cognitive presence.

Forums	Social presence	Teaching + Cognitive presence	Totals
Open Univ. (25: exact sciences)	57.64%	42.36%	100%
Open Univ. (25: humanities)	65.87%	34.13%	100%
Open Univ. (Average)	61.75%	38.25%	100%
Campus-based college (1: humanities)	63.72%	36.28%	100%

In this case, there is no significant difference $\{\chi^2(1)=0.174, p=.677\}$ between the distribution from the campus-based college course forum and the distribution for the Open University humanities forums.

Lastly, a revised population parameter, this time two-dimensional, that fits *all* previous and current findings was sought. The ratio between social presence *versus* combined teaching *and* cognitive presence for the 50 Open University forums (61.75 : 38.25) was tested (Table 2). No significant difference was found between this ratio and the ratio from (1) the Open University science forums $\{\chi^2(1)=0.54, p=.46\}$, (2) the Open University humanities forums $\{\chi^2(1)=0.58, p=.45\}$ and (3) the campus-based college forum $\{\chi^2(1)=0.09, p=.76\}$.

Extraordinarily, this ratio (61.75 : 38.25) is almost precisely, the golden ratio, phi (ϕ). Algebraically, the golden ratio is defined as the ratio between two variables, a and b, where: $(a + b) / a = a / b = \phi = 1.6180339\dots$

1. $(61.750 + 38.251) / 61.750 = 1.619\dots$ (99.94% approximation)
2. $61.750 / 38.251 = 1.614\dots$ (99.75% approximation)

Discussion

On the one hand, initial findings showed a very significant difference between the *overall* distributions of social, teaching and cognitive presence between the undergraduate history course forum analyzed at the campus-based college, and the calculated, three-dimensional population parameter for humanities forums in general. The near absence of cognitive presence in the college forum may possibly reflect institutional differences vis-a-vis teaching and learning. College students attended weekly lectures, had ample opportunity to talk with instructors and to establish friendships with classmates. Clearly the forum was not a primary resource for teaching and learning. Different dialogic behavior was seen in course forums at a distance based, Open University where students met less frequently with instructors and peers. In any case, findings from both studies show clearly the importance of "social presence" in asynchronous course forums, whatever the institution (e.g., Caspi & Blau, 2008; Gorsky & Blau, 2009; Vaughan & Garrison, 2006).

On the other hand, there is *no* significant difference between the ratio of social presence and the sum of teaching and cognitive presence between the forum analyzed at the campus-based college and the newly presumed, *two-dimensional* population parameter for humanities forums in general. Such a reduction to two dimensions has been justified theoretically (Gorsky & Caspi, 2005; Gorsky et al., 2008) on the grounds that, at the most abstract level, "communities of inquiry" include "subject-matter-oriented dialogues" (cognitive *and* teaching presence) and "non-subject-matter-oriented dialogues" (social presence).

Furthermore, findings indicate the possible existence of a two-dimensional population parameter for higher education, asynchronous course forums (Communities of Inquiry) that transcends academic discipline and level, group size and institutional difference that is the *Golden Ratio*. The Golden Ratio is not confined to mathematics. It has appeared in all the natural sciences as well as in art, music, and architecture (Livio, 2002). In the context of asynchronous course forums, the meaning of the ratio is unclear. However, whatever its meaning or practical implications, given that the golden ratio emerged from a data base of 4,890 nominal variables from the behavioral sciences is quite extraordinary.

References

- Caspi, A., & Blau, I. (2008). Social presence in online discussion groups: Testing three conceptions and their relations to perceived learning. *Social Psychology of Education*, 11(3), 323-346.
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *Internet and Higher Education*, 2(2-3), 87-105.
- Garrison, D.R., & Arbaugh, J.B. (2007). Researching the community of inquiry framework: Review, issues, and future directions. *Internet and Higher Education*, 10, 157-172.
- Gorsky, P., & Blau, I. (2009). Effective online teaching: A tale of two instructors. *International Review of Research on Distance Learning*, 10(3), 1-27.
- Gorsky, P., & Caspi, A. (2005). Dialogue: A theoretical framework for distance education instructional systems. *British Journal of Educational Technology*, 36(2), 137-144.
- Gorsky, P., Caspi, A., & Chajut, E. (2008). The theory of instructional dialogue: Toward a unified theory of instructional design. In R. Zheng & S. Pixy-Ferris (Eds.). *Understanding Online Instructional Modeling: Theories and Practices*. Hershey, PA: Idea Group, Inc. 47-68.
- Gorsky, P., Caspi, A., Antonovsky, A., Blau, I., & Mansur, A. (2010). The relationship between academic discipline and dialogic behavior in Open University course forums. *International Review of Research on Distance Learning*, 11(2).
- Livio, M. (2002). *The Golden Ratio: The story of Phi, the world's most astonishing number*. NY: Broadway.
- Vaughan, N., & Garrison, D. R. (2006). How blended learning can support a faculty development community of inquiry. *Journal of Asynchronous Learning Networks*, 10, Retrieved from: http://www.sloan-c.org/publications/JALN/v10n4/v10n4_vaughan.asp

Patterns as Facilitators for Knowledge Building in Learning Organizations

Christina Matschke, Knowledge Media Research Center, Konrad-Adenauer-Strasse 40, 72072 Tuebingen, Germany, c.matschke@iwm-kmrc.de

Johannes Moskaliuk, University of Tuebingen, Konrad-Adenauer-Strasse 40, 72072 Tuebingen, Germany, j.moskaliuk@iwm-kmrc.de

Franziska Arnold, Ulrike Cress, Knowledge Media Research Center, Konrad-Adenauer-Strasse 40, 72072 Tuebingen, Germany,

Email: f.arnold@iwm-kmrc.de, u.cress@iwm-kmrc.de

Abstract: Learning organizations encourage individual learning and knowledge building. According to Cress & Kimmerle (2008), individual and organizational knowledge co-evolve by externalization and internalization processes. However, these processes are more difficult for knowledge-in-use. We propose that patterns facilitate the exchange of knowledge-in-use by relating specific problems to solutions, and thus support the co-evolution of knowledge-in-use. The implementation of a pattern-based knowledge exchange tool in an organization is introduced and first experiences described.

Individual Learning and Organizational Knowledge Building

Learning organizations support both individual learning and organizational knowledge building, which is learning at the organizational level (Pedler, Boydell & Burgoyne, 1989). The Co-evolution model by Cress and Kimmerle (2008) points out that individual learning and knowledge building are intertwined. By the process of externalization, individuals contribute their knowledge into a shared digital artifact. The externalized knowledge then exists independently from the individual. Another person is now able to gather the information contained in the artefact and transfer it into that person's individual knowledge (internalization). The group collaborates through communication that occurs within the digital artefact, for example by modifying the artefact, reflecting it or commenting on it, thus leading to a co-evolution of both individual and organizational knowledge.

The co-evolution model has not specified the type of knowledge that evolves. It may, however, not be equally easy to exchange different types of knowledge. Little is known about the exchange of complex *knowledge-in-use*. Knowledge-in-use (De Jong & Ferguson-Hessler, 1996) is a combination of different types of knowledge that are necessary to perform a given task, solve a problem or handle a complex situation. Knowledge-in-use is embedded in daily challenges and in most cases implicit (Smith, 2001). Knowledge-in-use is highly *situated* (Greeno, 1998), and individuals build *situational knowledge*, that is, a relation between a situation that requires certain knowledge and the knowledge itself, about situations as they typically appear in a particular domain (De Jong & Ferguson-Hessler, 1996). This relation helps to identify relevant features of a current problem, to build an adequate representation of the problem and to retrieve additional (declarative, conceptual or procedural) knowledge to solve a problem.

Knowledge-in-use is often the most precious treasure of learning organizations. In contrast to declarative or conceptual knowledge, it is obviously not easy to externalize, internalize and collaboratively develop knowledge-in-use. The externalization of partly tacit knowledge-in-use is laborious, because individuals have to be aware of their individual work routines and experiences. They have to draw general conclusions from situated knowledge-in-use and present their knowledge in an abstract way, so it can be transferred to other situations and contexts. Internalization processes are also not trivial. Individuals will have to transfer abstract information to a concrete situation. If successful, externalized knowledge will help others to detect features of a current problem, retrieve and adapt relevant knowledge-in-use to a specific situation.

We propose that patterns support the co-evolution of individual and organizational learning by facilitating externalization, internalization and evolution of knowledge-in-use.

Patterns and Knowledge Building

Patterns are structured input formats that connect a problem to a solution, indicate the context where the solution is successful and stimulate reflection by asking on different forces and (wanted and unwanted) consequences. *Externalization* is supported by patterns, because they help experts to focus on invariant components of recurring problems and their successful solution, so that different individual experiences are integrated into an abstract pattern that explicates the key components (figure 1a). By the explicit description of problem and solution, experts are reminded of tacit parts of their knowledge-in-use and completeness of descriptions is improved. Patterns support the *internalization* of organizational knowledge-in-use by explicitly stating the situations where that knowledge is needed. Thus, knowledge-in-use is more easily activated in situations where the knowledge can be adapted. The *evolution* is supported by patterns, because they facilitate a common language and structure in knowledge descriptions. Experiences of different experts may be integrated

into one shared pattern, so knowledge will be reflected and revised in a collaborative process. If successful, this will lead to new, emergent organizational knowledge (figure 1b).

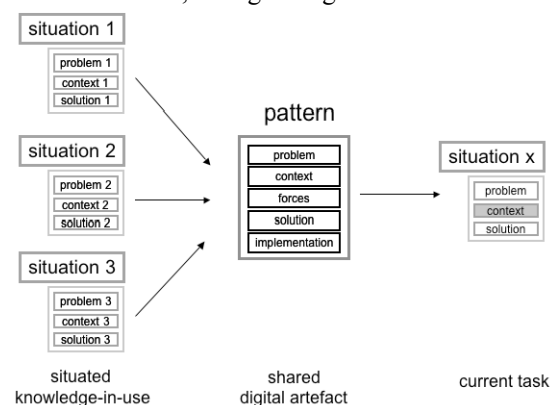


Figure 1a. Externalization of Knowledge-in-use.

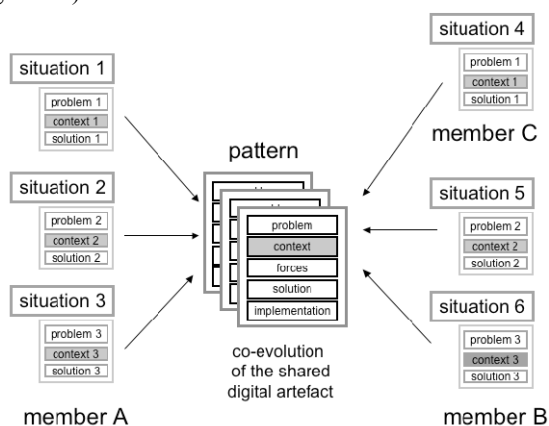


Figure 1b. Co-evolution of a Pattern.

Implementation of Pattern-based Knowledge Building

The project “Patterns and Tools for Non-Governmental Organizations” has implemented a pattern-based knowledge exchange platform in one of the biggest churches in Germany, the *Evangelische Kirche in Deutschland*, where 250,000 full-time staff members and about one million volunteers work together. A preliminary study indicated that there is a great amount of unshared individual knowledge-in-use, a strong organizational need for exchanging and developing this knowledge, and a readiness to use the internet.

The knowledge exchange platform consists of three main areas that are named “idea space” (a discussion board), “experience space” (a pattern-based collection of good practices) and “knowledge space” (a pattern-based wiki that is a collaborative written collection of reflected lessons learned). While contributions in the idea space are short and concrete, articles in the experience space describe single projects or situations. The patterns in the knowledge space are abstractions of individual experiences to an organizational collection of knowledge-in-use. The three spaces of the platform are strongly linked together in order to facilitate development from concrete ideas to more abstract, collaboratively written articles in the knowledge space. Mechanisms to support transformations between spaces are threaded and summarized discussions, links between spaces, networks that visualize articles related to similar topics and direct advertisements to contribute to the collaborative knowledge space. Moreover, professional profiles and the possibility to create groups support networking and collaboration.

In the 10 months after the launch of the platform, more than 2000 registered users could be won, not to name numerous anonymous readers of those pages that are accessible without registration (about 240 000 retrievals per month). In focus groups and online surveys, the platform is evaluated positively by the users, but psychological (e.g., reluctance to change someone else’s product, fear of losing face or getting personal feedback) and organizational barriers (e.g., lack of support by superiors, missing positive feedback for one’s contributions) make the ratio of active users compared to the passive readers seem small. 10% of the registered users have produced more than 300 articles in the experience space, 4% have written around 230 articles in the knowledge space, 3% have create more than 100 discussions. Collaborative actions take place in the form of modifying and commenting articles in the knowledge space (around 2% of the users) or participating in discussions in the idea space (4% of the users). 12 % of the users fill in their professional profile and 4% make use of the possibility to create contact to other users. These numbers of active contributors are comparable to other knowledge-sharing platforms, or to social software tools related to knowledge (e.g., Wikipedia). Future challenges will be to overcome the barriers that hinder active contribution and stimulate collaboration, so that other learning organizations may profit from a tool that fosters individual knowledge and knowledge building co-evolution.

References

- Cress, U., & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3(2), 105–122.
- De Jong, T., & Ferguson-Hessler, M. G. M. (1996). Types and qualities of knowledge. *Educational Psychologist*, 31(2), 105–113.
- Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist*, 53(1), 5–26.
- Pedler, M., Boydell, T., & Burgoyne, J. (1989). Towards the learning company. *Management Learning*, 20(1), 1–8.
- Smith, E. A. (2001). The role of tacit and explicit knowledge in the workplace. *Journal of Knowledge Management*, 5(4), 311–321.

Exploring the Role of Technology-Supported Peer Instruction in Student Understanding and Interaction in College Physics Classrooms

Elizabeth S. Charles, Jonghwi Park, Chris Whittaker, Dawson College, 3040 de Maisonneuve W., Montreal, Canada, H3Z1A4,

Email: echarles@dawsoncollege.qc.ca, jpark@place.dawsoncollege.qc.ca, cwhittaker@place.dawsoncollege.qc.ca

Nathaniel Lasry, John Abbot College, 21275 Rue Lakeshore, Canada, H9X 3L9, lasry@johnabbott.qc.ca

Abstract: Growing numbers of studies report positive gains in knowledge and conceptual understanding related to using Clickers as part of collaborative approaches to instruction. Our study examined the implications of modifying how students are encouraged to collaborate during such instruction. We present results of an ethnographic study involving two college-level physics classes. Using discourse analysis techniques, our results indicate that requiring different goals for clicker-mediated questioning produced differential student interactions and outcomes. Implications will be discussed.

Introduction

Student Response Systems, more often known as Clickers, have been widely used in post-secondary classrooms in North America. Clickers are a wireless device, which enables interaction between teacher and students by asking students to vote, discuss and compare their answers. Empirical studies have reported positive impacts of Clickers, including significant knowledge gain (Hake, 1998) and generally improved learning (Scriven, Chasteen & Duncan, 2009). Nonetheless, it is important to reiterate that clickers are not magic bullets (Lasry, 2008) but are effective if properly implemented with approaches such as Peer Instruction (Mazur, 1997). At the same time, the socio-cognitive literature suggests that the discourse produced around collaborative activities is a critical aspect of learning (Stahl, 2006). Our study aimed to examine these processes more closely and determine whether modifying the degree to which students were required to collaborate influenced their learning or the learning environment. Specifically, we looked at the implications of implementing two different approaches to peer instruction (PI) using clickers: (1) asking students to individually vote after short term discussions (*individual vote* treatment) and (2) requiring them to collectively vote after working together to come to consensus (*consensus vote* treatment). We were particularly interested in identifying factors that afford richer and more meaningful discourse, as well as study the implications of modifying the collaboration required in this activity.

Theoretical Background

Through socio-cognitive and socio-cultural lenses, learning can be described as a change that occurs from interactions with others and the context (e.g., Vygotsky, 1978). When such frameworks are applied to pedagogy the result is often the design of small group or whole class, cooperative and collaborative activities. Such activity relies on collective actions and development of *common ground* (Clark & Schaefer, 1989) and the convergence of meaning – i.e., *grounding*. We view consensus as a possible form of grounding. While it is now commonly taken that collaborative activities can promote learning, there is little in the education literature about the role that intentional grounding activities might have in determining ways collaborative discourse plays out.

Research Context

The study was a quasi-experimental design consisting of two introductory physics classes taught by the same teacher at the college level in an urban area in Canada. “Class A” consisted of 24 students (M=14, F=10) and “Class B” consisted of 30 (M=13, F=17), all between the ages of 17 – 19 years. The teacher employed the clicker-supported peer instruction where students are presented with a brief lecture (7-10 minutes) followed by a *ConceptTest*. A *ConceptTest* is a multiple-choice conceptual question designed to have answers reflecting well-documented misconceptions, alongside the correct answer. After individually answering a *ConceptTest* question, students are asked to turn to a classmate with a different answer, discuss the correctness of their answer in a small group, and individually vote their answer again – i.e., traditional PI approach. Class A students engaged in this traditional approach (individual vote); whereas Class B students were asked to come to consensus during their small group discussion and vote as a group (consensus vote). In both treatments, groups were made up of approximately 3-4 students. This clicker-mediated PI activity was regularly given to the students throughout the fall term in 2008. Learning gains were measured by the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) administered as a pretest and posttest.

Although the ANOVA results on the FCI data indicated no significant difference between the treatment groups in terms of their conceptual knowledge gain ($p=.65$), the researchers could not help but notice qualitatively significant differences in student discussion and dynamics between the two classes that employed different modes of clicker instruction.

Qualitative and Discourse Analysis

Observation data were recorded in field notes by the principal researcher during in-class observations: 18 sessions from Class A and 16 sessions from Class B. The field notes were edited and transferred to electronic form after each class. The field notes mainly recorded approximate times of notable activities, who initiated the activities (e.g., students or teacher), and descriptions of the activities. Finally, a case student group was selected from each class, which we will name SG-A and SG-B. The class discussions of these two groups were audio-taped and transcribed.

The analysis of the field notes suggested that students in Class B participated more actively in the class activity than students in Class A. For example, we identified student questions and comments as an indication of participation. These two items were identified in the field note data, coded as such and tabulated for the respective classes (Table 1). Specifically, Class B (consensus vote) students were twice as likely to initiate questions directed at the teacher compared to their peers in Class A (individual vote). Interestingly, the reverse was true for the student-led comments. Graphical representations will be shown on the conference poster.

Table 1: Descriptive statistics of student participation in Class A & Class B over 15 classes each.

Student generated participation	Class A	Class B (Consensus PI)
Questions over 15 classes	M = 2.8	M = 6.6
Comments	M = 0.6	M = 0.2

To further examine if there were any qualitative differences between the ways that the groups structured their interactions based on the different types treatments – individual vote vs. consensus vote – we selected several instances where both classes were required to discuss the answers to the same conceptual questions. The students in SG-A (individual vote) did not change much from the beginning to the end of the course. They presented their arguments in a systematic fashion and their interactions produced an almost “turn-taking” structure. Meanwhile, the interaction of students in SG-B (consensus vote) produced a very different structure, which might be characterized as an agentic-development. That is, students took on different roles as the course progressed and demonstrated an increasing sense of commitment to correctly answering and understanding the ConcepTest questions. Excerpts will be presented on the conference poster.

Discussion

This study explored the impacts of different types of peer instruction mediated by Clickers in an introductory physics course. The quantitative data did not reveal significant differences in the FCI results and exam grades of the two classes; however, findings indicated that students in Class B (consensus vote) spent more time on discussing physics concepts than those in Class A (individual vote). Furthermore, students in Class B showed more signs of active participation in collaborative discourse than those in Class A.

The findings suggest that forcing students to reach a consensus and vote in a group may play an important role as a stimulus to encourage them to collectively externalize their thinking and engage in grounding activities. In doing so, a deeper commitment to understanding is fostered and even perhaps a deeper sense of the available resources within the class community.

References

- Clark, H. H. & Schaefer, E. F. (1989). Contributing to discourse. *Cognitive Science*, 13, 259-294.
- Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force Concept Inventory. *The Physics Teacher*, 30, 141-158.
- Lasry, N. (2008). Clickers or Flashcards: Is There Really a Difference? *The Physics Teacher*, 46, 242.
- Mazur, E. (1997). *Peer Instruction: A User's Manual*. Upper Saddle River, NJ: Prentice Hall
- Scriven, M., Chasteen, S., & Duncan, D. (2009). A 'Strong Case' Exists for Classroom Clickers, letters to the editor, *Chronicle of Higher Education* 55(21).
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
- Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Acknowledgment

This study was supported by PAREA grant, Ministère de l'Éducation et du Loisir et du Sport, Quebec, Canada.

Collaboration at Scale: How and Why are Instructors Using Collaborative Learning Management System Tools?

Andrew E. Krumm, Richard J. Waddington, Steven Lonn, Stephanie D. Teasley,
University of Michigan, School of Education, 610 E. University, Suite 2211, Ann Arbor, MI 48109
Email: aekrumm@umich.edu, rjwadd@umich.edu, slonn@umich.edu, steasley@umich.edu

Abstract: This paper examines how and why university instructors use collaborative tools within learning management systems (LMS). Using questionnaire data from fifteen universities and system log data tracking instructors' use of an LMS at one university, we found that instructors' (1) perceptions of value for collaborative LMS tools are related to institutional context, (2) use of collaborative LMS tools varies between academic units within one university, and (3) perceptions of value for collaborative LMS uses are not consistent predictors for whether an instructor uses a collaborative LMS tool.

Introduction

Over the past ten years, colleges and universities have witnessed the rapid diffusion of learning management systems (LMSs) (Smith, Salaway, & Caruso, 2009). LMSs are a class of web-based technologies that support a wide range of functionalities such as posting assignments, managing grades, exchanging digital resources, and supporting student-to-student collaboration—all within a comprehensive online environment. The purpose of this paper is to better understand factors that affect an instructor's use of collaborative tools contained within an LMS. Given their wide-scale diffusion, LMSs offer a compelling case that can be used to better understand how and why instructors use collaborative tools to support learning. Moreover, identifying factors that may affect an instructor's use of collaborative LMS tools represents a line of research that can lead to specific points of leverage for future computer-supported collaborative learning (CSCL) interventions and provide important insights into the implementation and scalability of CSCL tools (e.g., Roschelle, Tatar, Shechtman, & Knudsen, 2008).

Methods

To explore instructors' use of collaborative LMS tools, this study used questionnaire data collected from 15 universities and system log data that tracks instructors and students' use of LMS tools from one university. We examined instructors' perceptions and actual use of the following LMS tools: Chat, Discussion, Forums, and Wiki. The Chat tool supports synchronous interaction between and among participants on a course site; the Discussion tool supports threaded, asynchronous interaction; the Forums tool is similar to the Discussion tool, but has several more finely grained options and permission settings; and the Wiki tool supports collaborative document creation by all members of a course site. This study is organized around the following research questions: What factors help to explain an instructor's use of collaborative LMS tools (RQ #1)? To what degree do instructors across 15 universities value collaborative LMS tools and uses differently (RQ #2)? To what degree do differences in LMS use exist between academic units within one university (RQ #3)? To what degree are instructors' beliefs about LMS tools related to their actual use of collaborative LMS tools (RQ #4)?

Our analysis began by examining instructors' perceptions of value for collaborative LMS tools as captured by a questionnaire distributed to instructors at 15 universities. To analyze questionnaire data we developed several categories that captured an institution's context: International or US; enrollments greater or less than 10,000 undergraduate students; and research, teaching, or mixed orientation. Using these categories, we compared instructor's perceptions of value for collaborative LMS tools (RQ#2).

After identifying patterns in questionnaire data, we focused on one institution and analyzed instructors' use of collaborative LMS tools. To examine differences in LMS use within and between academic units (RQ#3), we developed variance components models using the following nesting strategy: tool use/non-use modeled at Level-1, instructors at Level-2, and academic units at Level-3. After decomposing the variance in LMS use across multiple academic units, we included several predictor variables in multiple, conditional 3-level hierarchical logistic regression models that were constructed to examine the likelihood of an instructor's use of individual collaborative LMS tools (RQ#1). The following variables were included in prediction models: dummy variables indicating an instructor's job category (graduate student instructor, tenure-track, or lecturer/other); a dummy variable indicating gender; a 5-point Likert scale variable indicating one's perceived value of LMS for course activities; a 5-category variable indicating the number of courses for which one has used the LMS; a 5-category variable addressing how often one visits the LMS in an academic term; a 4-category variable indicating how much one uses generic information technologies for course activities; a 5-category variable assessing how many years one has been an instructor; a collaborative LMS use factor score that was comprised of four items; and the number of students enrolled in a course. These prediction models, along with

several cross tabulations of system log data with an instructor's perceptions of value of collaborative LMS tools, were used to assess the degree to which an instructor's beliefs about LMS tools are related to their use of specific LMS tools (RQ#4).

Results and Discussion

Results from the multiple 3-level hierarchical logistic regression models, which are reported as odds ratios (OR), revealed no consistent predictive factors for the collaborative LMS tools examined (RQs #1 & #4). Across each of the four collaborative LMS tools, the constructed factor score was a significant predictor for the Wiki tool, where, holding all else constant, instructors who highly score highly on the factor score are less likely to use the Wiki tool (OR = .806; $p < .05$). The numbers of years for which an instructor has taught was a significant negative predictor for the Discussion tool (OR = .899; $p < .001$), which means that the longer one has been an instructor, the less likely he or she is to use this tool. How much technology an instructor self-reported using in his or her classroom was a significant positive predictor for the Forums tool (OR = 1.957; $p < .01$). How often an instructor self-reported visiting the LMS was a significant positive predictor for one's use of the Forums (OR = 1.417; $p < .01$), Chat (OR = 1.719; $p < .001$) and Discussion (OR = 1.297; $p < .01$) tools. The number of courses for which one has used an LMS was a significant positive predictor for the Wiki tool (OR = 1.309; $p < .05$). How much one values an LMS for course activities as well as gender were not significant predictors across any model. Differences between job categories among instructors were significant for the Discussion tool (OR = 1.912; $p < .001$), whereby tenure-track instructors, on average, were more likely to use this tool as compared to the reference category, lecturer/other. The number of students enrolled in a course was a significant negative predictor only for the Discussion tool (OR = .997; $p < .001$).

While we did not identify consistent explanatory variables across the four collaborative LMS tools, we did identify several important indicators that speak to how and why instructors use these tools. For example, comparisons across each of the institutional categories reveals that (1) instructors in international schools value collaborative LMS uses more than instructors in US schools, (2) smaller schools value collaborative LMS uses more than larger schools, and (3) non-research institutions value collaborative LMS uses more than research institutions (RQ #2). Differences between academic units within one university on the probability that an instructor uses a specific LMS tool were identified (RQ #3). Between-academic unit variation was minimal, however, relative to other sources of variation in that, on average, 6 times more variation was present *within* academic units as compared to *between* academic units.

In further analyses of the relationships between perceptions of collaborative LMS uses and actual use of the system (RQ#4), instructors who more highly valued collaborative LMS tools, on average, (1) deployed one more LMS tool of any type on their course site, (2) used at least one collaborative LMS tool as compared to the more typical instructor who did not use any, (3) had 10.66% less of their total course site activity dedicated to only one tool, and (4) averaged 53.38 more per-student events than those instructors who did not highly value collaborative LMS tools.

Conclusion

The purpose of this study was to better understand how and why instructors use collaborative LMS tools in their classrooms. Examining the use of collaborative technologies within an LMS presented several advantages: (1) capture a large number of instructors and (2) simultaneously examine users and non-users of collaborative tools. Based on the findings from the hierarchical logistic regression models, no single factor was predictive across all collaborative LMS tools, which signals that collaborative LMS tools may be distinct enough from one another and may afford different uses in classrooms that these tools do not easily align with the individual traits of an instructor.

A great deal of CSCL research examines learning environments and tools on a relatively small scale, and the limited scales at which a great deal of CSCL research is conducted often prohibits a comprehensive understanding of why an instructor would chose to deploy these tools in his or her classroom (e.g., Dillenbourg, 1999). Therefore, measuring actual use of collaborative tools—at scale—represents an important line of inquiry that can inform the diffusion and adoption of CSCL tools.

References

- Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1-19). Amsterdam: Pergamon.
- Roschelle, J., Tatar, D., Shechtman, N., & Knudsen, J. (2008). The role of scaling up research in designing for and evaluating robustness. *Educational Studies in Mathematics*, 68(2), 149-170.
- Smith, S. D., Salaway, G., & Caruso, J. B. (2009). *The ECAR study of undergraduate students and information technology, 2009*. Boulder, CO: EDUCAUSE.

Fostering Critical Thinking in Science Museums through Digital Augmentations

Susan A. Yoon, University of Pennsylvania, Philadelphia, PA, yoonsa@gse.upenn.edu

Karen J. Elinich, The Franklin Institute, Philadelphia, PA, kelinich@fi.edu

Joyce Wang, Christopher Steinmeier, Jackie Van Schooneveld, University of Pennsylvania, Philadelphia, PA

Email: joyce.s.wang@gmail.com, cst@dolphin.upenn.edu, jackieflicker@gmail.com

Abstract: This study investigates the effects of augmented reality visualizations on conceptual understanding in a science museum setting. We build on previous studies of visitor behaviors to analyze how participants engage in two designed conditions illustrating learning that occurs with and without the digital augmentation. Results show increased cognitive (critical thinking) skills when the augmentation is enabled that may lead to increased conceptual gains. We illustrate how this research contributes to three important areas of identified need in the informal science education literature.

Introduction

The recent National Research Council report on learning science in informal environments (Bell et al., 2009) examines the potential that non-school settings have for engaging learners in real-world scientific investigation. The NRC report and others (e.g., Rennie et al., 2003) highlight three areas of need for systematic studies. First, there is a need for more research and clear evidence that indicate improved conceptual and cognitive gains. Second, as more educational technologies are being used to assist in the development of conceptual knowledge, research is needed to know how digital platforms improve the learning experience in these settings. Finally, while designed interactive activities have been shown to increase scientific skills such as manipulating and observing, higher order inquiry skills such as critical thinking and theorizing are less often demonstrated.

Theoretical Considerations

Although digital devices have been tested in museum settings (Szymanski et al., 2008), little is known about their conceptual impacts. This is partly due to the free-choice, episodic nature of informal learning, which makes capturing and measuring learning gains difficult. Researchers have also attributed challenges in promoting deep learning in informal settings to the nature of visitor experiences. For example, McManus has characterized visitor behaviors in terms of “hunter-gatherer groups who actively forage in the museum to satisfy their curiosity about topics and objects that interest them” (1994, p. 91). McManus suggests that intended objectives can still be met if the interest levels are high enough. Unfortunately, many devices are never attended to sufficiently for learning impacts to take effect. Some literature highlights the potential for augmentations to enrich learning events to encourage genres of critical thinking like reflection in a museum setting (Price & Rogers, 2004). However, little empirical research demonstrates this effect. As the importance of fostering critical thinking skills grows (Luke et al., 2007), we are interested in promoting them through augmentations.

Methodology

The investigation used a digitally augmented device called “Be the Path” that illustrates electrical conductivity and circuits. Participants for the study ($N=40$) were recruited from 6th and 7th grade classes from three schools located in a high needs urban school district with an average of 92% of students qualifying for free or reduced price lunch. Students were randomly assigned to two condition groups. Condition 1 (C1, $n=18$) served as the control with no digital augmentation. Condition 2 (C2, $n=22$) encountered the digital augmentation.

Three data sets were collected and analyzed through a mixed-methods approach: time on task; a pre- and post-intervention conceptual knowledge survey; and observation field notes which were coded using the Critical-Thinking Skills Checklist described in Luke et al. (2007). Students’ time on task averaged 2.7222 minutes for C1 and 3.2273 minutes for C2. A t-test analysis revealed no significant difference between the means. Figure 1 shows pre- and post-intervention conceptual knowledge survey mean scores. For C1, the difference in mean scores was .3889 with a standard deviation of 1.8194. A repeated-measures ANOVA indicated no significant increase between pre- and post-intervention ($p=.377$). For C2, the difference was .7273 with a standard deviation of 1.0771. A repeated-measures ANOVA indicated a significant increase between pre- and post-intervention surveys ($p=.005$) with an effect size of .323. These results imply that, although C2 students didn’t spend significantly more time with the device, the augmentation’s impact may have helped to improve understanding. Figure 2 shows a comparison of the total frequencies obtained between the conditions for each component, which were adjusted for equal n . Students in Condition 2 did better in four of the seven skills. However, a 2 x 2 chi-square analysis revealed that only Interpreting showed a significant difference, $\chi^2=3.367$, $p=.067$. Differences in frequencies observed for all other components were not significant.

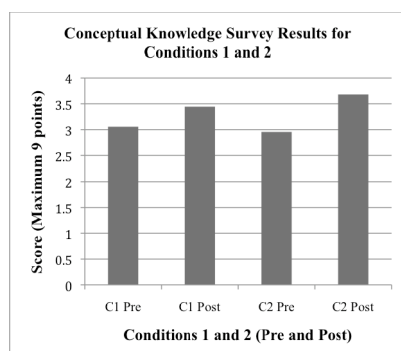


Figure 1. Mean Raw Scores for Pre- and Post-Intervention Conceptual Knowledge Surveys.

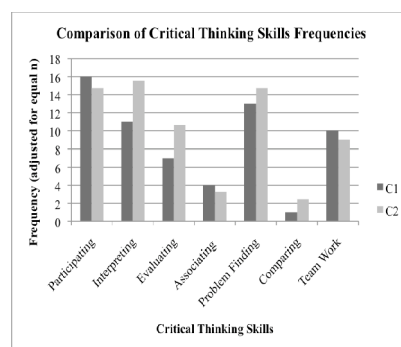


Figure 2. Frequencies of Critical Thinking Skills Observed in Conditions 1 and 2.

Discussion

Our goal was to investigate how digital augmentations improve conceptual understanding and cognitive skills given the specific nature of informal learning. We hypothesized that engagement would be longer and deeper when augmentations were used. When we analyzed the field notes for critical thinking skills, we found that students were better able to interpret the scientific phenomenon which may have influenced conceptual gains. This makes sense in that once the students were able to close the circuit by placing their hands in the appropriate configuration, digital electrons flowing around the circuit appeared, which may have served as an important learning scaffold. Characterizing digital augmentations as learning scaffolds is a fruitful approach in that researchers in the learning sciences have written extensively about how scaffolds embedded in digital platforms can enhance learning (e.g., Scardamalia, 2002; Quintana, 2004). In a study of a handheld augmented reality game, Klopfer and Squire (2008) found that students were able to solve simple problems, but required additional teacher supports to resolve more complex issues. Similarly, John and Lim (2007) reviewed medical training augmentations and found that although students learned from the experience, outcomes were enhanced when combined with other pedagogical scaffolds. In future iterations of this study, we focus on increasing the numbers and kinds of scaffolds and also investigate how those scaffolds are best adapted to informal learning.

References

- Bell, P., Lewenstein, B., Shouse, A., & Feder, M. (Eds.). (2009). *Learning Science in Informal Environments: People, Places and Pursuits*. Washington, DC: National Academy Press.
- Klopfer, E. & Squire, K. (2008). Environmental Detectives – the development of an augmented reality platform for environmental simulations. *Education Technology Research and Development*, 56(2), 203-228.
- John, N. & Lim, I. (2007). Cybermedicine tools for communication and learning. *Journal of Visual Communication in Medicine*, 30(1), 4-9.
- Luke, J., Stein, J., Foutz, S., & Adams, M. (2007). Research to practice: Testing a tool for assessing critical thinking in art museum programs. *Journal of Museum Education*, 32(2), 123-136.
- McManus, P. (1994). Families in museums. In L. Miks & A. Zavala (Eds.) *Towards the museum of the future*, (pp. 81-118). London: Routledge Press.
- Price, S., & Rogers, Y. (2003). Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. *Computers & Education*, 43, 137-151.
- Quintana, C., Reiser, B., Davis, E., Krajcik, J., Fretz, E., Duncanc, R., Kyza, E., Edelson, D., & Soloway, E. (2004). A scaffolding design framework for software to support science inquiry. *Journal of Learning Sciences*, 13(3), 337-386.
- Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Towards an agenda for advancing research on science learning in out-of-school settings. *Journal of Research in Science Teaching*, 40(2), 112-120.
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal Education in a Knowledge Society* (pp. 67-98). Chicago: Open Court.
- Szymanski, M., Aoki, P., Grinter, R., Hurst, A., Thomton, J. & Woodruff, A. (2008). Sotto Voce: Facilitating social learning in a historic house. *Computer Supported Cooperative Work*, 17(1), 5-34.

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. 0741659. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Investigating Different Critical Thinking Tests in an Authentic Inquiry

Jing Leng, Faculty of Education, The University of Hong Kong, Hong Kong, lengjing2001@gmail.com

Abstract: This paper aims to examine different critical thinking tests in an authentic context. This is a case study of Humanities course in a Hong Kong secondary school where the teacher places emphasis on critical thinking elements in the curriculum design and is also adopting collaborative inquiry in his/her teaching. Various measurements are employed to test students' critical thinking ability, and results of these critical thinking tests and the consistency among them are reported.

Introduction

Authentic inquiry is widely hailed as essential and desirable for learning in the 21st century (Kuhlthau, Maniotes, & Caspari, 2007). Computer-supported Collaborative Learning (CSCL) environments have great potential to support students to share and deepen their ideas online, as well as engage in authentic problems. According to Bereiter (2002), students can develop critical thinking through engaging in knowledge building, where explicit instruction on general critical thinking criteria is needless. In this study, the mixed approach (See Ennis, 1989) is adopted that some critical thinking skills are taught in separate mini-lessons, and students are also provided with an immersive environment for solving authentic problems. Although a great deal of measurements is developed to measure some aspects of critical thinking, the work reported in this paper is motivated by the central problem: Is there consistency in different critical thinking tests, and which one can best reflect students' critical thinking ability during the inquiry unit? This paper presents a case study in a secondary school humanities class in Hong Kong.

Authentic Inquiry in CSCL

Computer-supported Collaborative Learning (CSCL) is emerging as an important area of study in the interdisciplinary field of learning sciences (Sawyer, 2006). CSCL refers to situations where two or more people learn collaboratively together using computers. The networked platform offers great potential for students and teachers to implement collaborative inquiry in their classrooms. During the authentic inquiry, participants generate original research questions, and collect required information and conduct experiments or analyses so as to arrive at their own conclusions (Hanegan & Bigler, 2009). According to Chinn & Malhotra (2002), there is a lack of scientific method available to evaluate authentic inquiry. While many scholars in the field of CSCL embrace learning and collaboration, knowledge building is one of the earliest attempts that shape the field of CSCL (Koschmann, 2003). According to Scardamalia (2002) and Bereiter (2002), knowledge building is the progress where knowledge advances in the human society, while learning occurs as a by-product. There is a networked system designed for collaborative knowledge building (Knowledge Forum®, KF in short). With the shared discourse network, students' ideas and theories are displayed by graphics or notes as conceptual artifacts. Educators who employed KF generally prefer to give students some authentic problems for discussion, such as global warming, energy crisis (Leng, Lai, & Law, 2008). Despite substantial variation, many open-ended collaborative learning activities such as authentic inquiry share the common goal of achieving knowledge advancement and have the potential to facilitate collaborative knowledge building.

Critical Thinking

The philosophical tradition of critical thinking can ascend to ancient times of Socrates (Paul, 1995). There are numerous works done to conceptualize the term critical thinking (Ennis, 1987; Facione, 1998). The modern history of critical thinking, can be traced back to John Dewey coining the term of "reflective thinking" in 1930s. Based on Dewey's ideas, many theorists contribute to the development of critical thinking in the ensuing years (Ennis, 1996; Lipman, 1988; McPeck, 1981). Ennis is one of the most influential researcher in this field. According to Ennis (1985), critical thinking is "reasonable reflective thinking that is focused on deciding what to believe or do" (p. 45). Besides possession of the relevant skills of critical thinking, one needs to be disposed to use those skills in appropriate situations (Fisher, 2001). In addition, McPeck (1981) contends that specialized knowledge within the field is also requisite to critical thinking.

In order to capture the important elements of critical thinking, there are three tests employed in this paper: The Cornell Critical Thinking Test, Level X (CCTT; Ennis & Millman, 1985), The Inventory of Belief and Critical Thinking Disposition (IBCTD; Yeh, 1999), and the adapted Ennis-Weir critical thinking essay test (Ennis & Weir, 1985). Both CCTT and IBCTD are standardized tests, while the former test is used to measure critical thinking skills, the latter is employed to measure critical thinking dispositions. The Ennis-Weir is

adopted as an open-ended test to measure the logical dimension of critical thinking, including seven critical thinking competencies such as relevance, appropriate use of authoritative sources, appropriate reasoning.

Design and Method

One teacher and his students (32 students) are involved in this study. The classroom context for this study is one in which the teacher tries to apply knowledge building as a pedagogical treatment to promote students' critical thinking skills and dispositions. Both the teacher and students have no previous experience in adopting the online platform KF to support their authentic discussions. The two tests on critical thinking skills and dispositions are administered at the start and the end of the inquiry unit respectively so that possible changes in students' critical thinking could be observed over the duration of the learning module. In order to promote students' critical thinking skills and deepen their understanding on other group's design, this study modifies the critique form to an essay test on critical thinking. Thirty students in the classroom have taken the pre- and post-test on critical thinking skills and dispositions for the designed learning module. For peer critique forms, two group presentations are selected randomly for analysis purpose. Twenty-eight critique forms are collected on their responses to the two group's presentation.

Results and Discussions

This paper examines two famous critical thinking tests focusing on skills and dispositions respectively, and also attempts to design an essay tests incorporated with course content. These various tests on critical thinking, though different in format, can measure separate aspects of critical thinking. The analysis has been done to explore the relationship between the standardized critical thinking tests and the essay test designed in a real inquiry context. As a result, inconsistency is found between those different tests. The results of CCTT and IBCTD show that students' critical thinking ability seem to remain unchanged, even after experiencing multiple inquiry tasks. In the essay test, students who represent their ability in using multiple critical thinking competencies are very likely to score high. It is also noted that students who excel others in *overall strength of the argument* signify their proficiency in argument appraisal. The similar situation is happened to the competence of *appropriate reasoning*, and *appropriate use of authentic sources*. We may infer that teachers need to focus on teaching students how to offer good reasons and judge the overall strength towards one's argument, in order for students to achieve maximum performance in authentic tasks on critical thinking.

References

- Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Lawrence Erlbaum.
- Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, 86(2), 175-218.
- Ennis, R. H. (1985). A logical basis for measuring critical thinking skills. *Education Leadership*, 43(2), 44-48.
- Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. Barton & R. J. Sternberg (Eds.), *Teaching Thinking Skills: Theory & Practice* (pp. 9-26). New York: W. H. Freeman and Company.
- Ennis, R. H. (1989). Critical thinking and subject specificity: clarification and needed research. *Educational Researcher*, 18, 4-10.
- Ennis, R. H. (1996). *Critical thinking*. Upper Saddle River, NJ: Prentice-Hall.
- Ennis, R. H., & Millman, J. (1985). *Cornell critical thinking test, level X*. Pacific Grove, CA: Midwest Publications.
- Ennis, R. H., & Weir, E. (1985). *The Ennis-Weir critical thinking essay test*. Pacific Grove, CA: Midwest Publications.
- Facione, P. A. (1998). *Critical thinking: What it is and why it counts*. Millbrae, CA: California Academic Press.
- Fisher, A. (2001). *Critical thinking: An introduction*. Cambridge: Cambridge University Press.
- Hanegan, N. L., & Bigler, A. (2009). Infusing Authentic Inquiry into Biotechnology. *Journal of Science Education and Technology*, 18(5), 393-401.
- Koschmann, T. (2003). Computer-supported collaborative learning. In J. W. Guthrie (Ed.), *Encyclopedia of education* (2nd ed., pp. 468-471). New York: Macmillan Reference.
- Kuhlthau, C., Maniotes, L., & Caspari, A. (2007). *Guided Inquiry: Learning in the 21st century*. Westport, CT: Libraries Unlimited.
- Leng, J., Lai, M., & Law, N. (2008). Characterizing patterns of interaction in knowledge building discourse. In T.-W. Chan, G. Biswas, F.-C. Chen, S. Chen, C. Chou, M. Jacobson, Kinshuk, F. Klett, C.-K. Looi, T. Mitrovic, R. Mizoguchi, K. Nakabayashi, P. Reimann, D. Suthers, S. Yang & J.-C. Yang (Eds.), *Proceedings of the 16th International Conference on Computers in Education (ICCE 2008)* (pp. 351-356). Taipei, Taiwan.
- Lipman, M. (1988). *Philosophy goes to school*. Philadelphia: Temple University Press.
- McPeck, J. E. (1981). *Critical Thinking and Education*. New York: St. Martin's Press.
- Sawyer, R. K. (2006). *Cambridge Handbook of the Learning Sciences*. Cambridge, UK: Cambridge University Press.
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago, IL: Open Court.

The Development of Life Transition Skills in Inter-Life: A Novel, 3-dimensional Virtual Learning Environment

Alison M. Devlin, Vic Lally, The Interdisciplinary Science, Education, Technologies and Learning Research Group, School of Education, University of Glasgow, UK,

Email: Alison.Devlin@Glasgow.ac.uk; Victor.Lally@Glasgow.ac.uk

Madeleine Sclater, SOLSTICE, Edge Hill University, Ormskirk, UK, madeleine.sclater@edgehill.ac.uk

Karla Parussel, Department of Mathematics and Computing Science, University of Stirling, UK, kmp@cs.stir.ac.uk

Abstract: Inter-Life is a novel multi-modal, immersive virtual learning environment for the development of life transition skills in young people. Current policy highlights the role of technology in collaborative learning in a social and interactive manner. This article illustrates how Inter-Life is appropriated by a group of Looked After and Accommodated Children (LAAC) to help shape their own learning. Such a learner centred approach resonates with the current policy debate on the role of technology in education.

Introduction

The potential of immersive, 3-dimensional virtual worlds for the social construction of knowledge and deep learning is now being investigated (Bronack, Riedl & Tashner, 2006; Dalgarno & Lee, 2010). However, relatively little work has been done on the impact of such technology on learning with young people who are in the care of government local authorities, known as Looked After and Accommodated Children (LAAC) (Connelly & Chakrabarti, 2007). Inter-Life is an interdisciplinary research project that aims to provide a safe online space for young people to work together on activities that contribute to the development of life transition skills such as: self-confidence, negotiation and mediation skills, empathy, team work and problem solving skills. Inter-Life Island-2 (ILI-2) is a safe and secure virtual island environment where young people can collaborate and, *through the processes of participation in authentic learning activities*, develop skills to help them navigate a range of real-world transitions. IL-12 is an extensively modified virtual, 3-dimensional immersive environment based on the Second Life™ platform.

There is current discourse in the literature about the paradigmatic shift in education from a traditional instructional model to a more personalised, learner-centred model in which life skills are a prerequisite for navigating both social and educational transitions in the knowledge age against a framework of lifelong learning (Robertson, 2005; Ahier & Moore, 1999). Another theme within educational policy is that of inclusion and capturing the 'voice of the child' but work involving technology has been limited in this area since young people in care are often considered "hard to reach." Technology enhanced learning environments may represent a novel tool that resonates with their 'digital' culture more readily than traditional approaches.

Aim

The aim of the present study was to determine if young people, who are presently in care, would experience the context of Inter-Life as a safe space to address their real life transition challenges and whether this changed as a result of participating in authentic learning activities in Inter-Life. The Inter-Life project is set within a social constructivist learning framework in which knowledge is built in an interactive environment and meaning is anchored in a situated context and so virtual immersive environments represent an attractive tool for deep and meaningful learning with implications for real-life. The project also draws on Lave and Wenger's community of practice theoretical framework (Lave & Wenger, 1991).

Methods

A series of twelve, 'blended' Inter-Life workshops was run between March 2010–June 2010 in which a group of young people (age range, 13-17 years) participated in a mixture of open-ended and structured educational activities, both face to face and 'in-world' in Inter-Life. This paper draws on data from the Inter-Life workshop observations and the workshop chat logs (n=12) collected automatically through the integrated data gathering tools. In addition, semi-structured research interviews were conducted with a sample of young people and their parents/carers. These methodologies are in keeping with social learning theory which favours "multi-voicedness" and "rich descriptions" from learners of their experiences. All data was imported into NVivo 8 and analysed in an inductive, iterative fashion using a social constructivist analytical lens in order to answer the research questions, and analysis was conducted across multiple data sources in order to triangulate the research findings (Erickson, 1986; Miles & Huberman, 1994).

Results

Data analysis indicated the development of life transition skills in the young people through participation in the open-ended and structured Inter-Life learning activities. For example, at one workshop there was evidence of fluid leadership and one young person reflected on trying to support a peripheral participant by helping and encouraging this new member to become part of the learning community:

You know how we had all started off and everybody was doing their own thing but then John and that were then brought inand everybody was ahead...whereas John was..... *I was trying to help him....* but he was getting frustrated because of *You are all ahead, how am I supposed to build my house?*
(Research interview, Young Person A)

The same young person, upon reflection, indicated how Inter-Life had helped with the development of their self-confidence:

I wasn't as confident, I don't think.....*until I came to Inter-Life....*
(Research interview: Young Person A)

Data analysis also indicated the development *over time* of negotiation skills, as well as empathy, self-awareness, team-work and problem-solving skills. The young peoples' confidence developed such that they were able to undertake planning and leadership tasks to solve emergent problems. For example, two young people worked together to establish rules for 'turn-taking' when asking questions 'in-world' since the synchronous nature of the interactive chat was causing some tension within the group. Another young person was capable of leading a group activity about countries of the world and their cultures, thereby demonstrating leadership and mentoring skills, as illustrated in the chat log:

Can everyone please come to me and tell me which country they would like to do, for example Mexico?
(Workshop chat log 12: Young Person B)

Conclusions

The present study provides evidence to suggest that young people can appropriate Inter-Life as a new ecology for learning in a meaningful participatory manner and work in a collaborative fashion in order to develop life transition skills. Furthermore, this is one of the first studies in which Looked After and Accommodated Children (LAAC) have worked together in a 3-dimensional virtual learning environment in an inclusive fashion.

At a time when there is a paradigmatic shift in models of learning (Robertson, 2005), this paper has shown how Inter-Life can support situated learning in a personalised fashion and contribute to meaningful learning. In conclusion, the present study provides some new empirical evidence of learning in authentic settings which is in alignment with the current debate on the role of technology as an essential tool to facilitate social learning and which resonates with current educational policy initiatives.

References

- Ahier, J. & Moore, R., (1999). Post-16 education, semi-dependent youth and the privatisation of inter-age transfers: re-theorising youth transition. *British Journal of Sociology of Education*, 20, 515-530.
- Bronack, S., Riedl, R. & Tashner, J., (2006). Learning in the Zone: A social constructivist framework for distance education in a 3-dimensional virtual world. *Interactive Learning Environments*, 14(3), 219-232.
- Connelly, G. & Chakrabarti, M., (2007). Improving the educational experience of children and young people in public care: A Scottish perspective. *International Journal of Inclusive Education*, iFirst Article, 1-15.
- Dalgarno, B. & Lee, M., (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, 41(1), 10-32.
- Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 119-161). New York: MacMillan Press.
- Lave, J. & Wenger, E., (1991). *Situated Learning: legitimate peripheral participation*. Cambridge: Cambridge University press.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
- Robertson, S.L. (2005). Re-imagining and rescripting the future of education: global knowledge economy discourses and the challenge to education systems. *Comparative Education*, 41(2), (151-170).

Acknowledgments

Inter-Life is funded by EPSRC/ESRC (UK) RES-139-25-0402.

How Do Instructors Design Classroom-wide Interactive Formative Assessments? A Field Study with 18 Schools

Neema Moraveji, Roy Pea, Learning Sciences and Technology Design, Stanford University
 Email: neema@stanford.edu, roypea@stanford.edu

Abstract: We present the results of a study assessing how instructors used an authoring tool called Mischief to create formative assessments. The study, run over 3.5 months with 18 schools, 50 instructors, and 3233 students, shows how instructors used different features to achieve different participation structures and pedagogical goals. When compared to individualistic activities, collaborative activities targeted higher cognitive levels of assessment. These results motivate code-free authoring environments for novices to create multiuser activities of collaborative, rather than individual, assessments to target higher cognitive levels.

A Platform for Large-group, Interactive Formative Assessment

Individual studies and meta-reviews such as (Black, Wiliam, 1998) have shown that formative assessment produces significant learning gains especially for low-achieving and learning-disabled students. Frequent, short assessments (as would be possible were more instructors able to create them) are better than infrequent long ones. Examples of effective techniques include: ascertaining the status and extent of existing student understanding, triggering peer discussion and instruction, having all students (rather than individual volunteers) generate ideas or answers, and having students contribute possible answers before and after instruction.

Our approach to enabling instructor-designed interactive formative assessment has been to create a platform for instructors to design their own activities that leverage rich input from students *en masse*. The name of the tool is Mischief (the collective noun for ‘mice’) and it works by giving each student a wired or wireless mouse and connecting those mice all to a single computer whose display is being projected at the front of the room. The system is described in detail in (Moraveji, *et al*, 2008). Each cursor maps to a unique cursor and multiple cursors can be on-screen simultaneously. Anywhere between 5-30 mice are used in a single classroom. When necessary, students can share a single mouse in a small group or take turns. Mischief reads Powerpoint files and, according to metadata appended by the instructor inside each slide, renders slide contents with interactive components (described in detail below). The system maintains answers and cursor identities during a classroom session. The instructor, using a ‘supermouse’ and her keyboard, orchestrates the presentation of instructional content where each slide is a separate activity.

This study aims to a) understand what pedagogical goals instructors aim to fulfill using such activities, b) understand how they try to reach those goals, c) and how their assessments, once designed, are used in class. To answer these, we conducted a field study spanning 3.5 months, 18 schools, 50 instructors, and 3233 students.

Field Study

We deployed the technology to schools and instrumented it to log data that our team members collected manually, every several weeks. Our team contacted teaching institutions in several Southeast Asian countries. This call made the intent of the study known and included a video of the system. The study ran from Jan. 10, 2009 – Apr. 30, 2009. Schools and instructors were not compensated. We did not purchase mice or USB cables for schools. The instructors volunteered and were proficient with Powerpoint. This included 50 instructors in 18 schools (7 primary, 11 secondary). 3233 students used the system for approximately 310 classroom hours in total. Each row in each log file contained the following columns of data: time since session started (in milliseconds), unique cursor identifier, position of cursor on screen, event type (mouse movements, clicks, and keys typed), object type under the cursor, coordinates of said object, and unique Powerpoint object identifier.

Results

Based on a representative sample, 49.7% of the slides instructors created were interactive, 18% were drag-and-drop, 46.1% multiple-choice, 28.7% short-answer, and 7% drawing. There were two types of participation structures: ‘Individual’ activities where a group of students does individual tasks in parallel. ‘Collaborative’ structures are those where the students interact with the same objects towards the same overall goal.

The Pedagogical Goal of a slide was based on Bloom’s Taxonomy of Cognitive Levels (Bloom, 1956). We consolidated each pair of proximal levels into three meta-levels. We used Bloom’s taxonomy to identify the instructor’s *intention*. It does not describe how the slide was actually *used* but, rather, how it was intended to be used. How is pedagogical goal related to participation structure? This question is interesting because if instructors are using collaborative assessments for higher pedagogical goals, this motivates improvement of the

way such assessments are designed. Thus, if authoring tools ease the design of collaborative assessments, classrooms would have higher-level assessments in them, even in resource-poor schools.

Table 1: Two-way associate table of associations between Pedagogical Goal and Participation Structure of instructor-designed formative assessments based on a representative sample.

Table 2: Interface widgets instructors used to create assessment types (e.g. 2I = ‘Level 2, Collaborative’). Note this table contains only interactive slides (201 of the 440 total slides in our sample).

Participation structure	Pedagogical goal			Ped. level	Part. structure	Drag-drop	Multiple choice	Short answer	Draw	All			
	Level 1	Level 2	Level 3										
Individual	87	49	10	1	Indiv.	5	14	64	17	21	1	6	87
	(82.1%)	(62.9)	(58.9)		Collab.	9		1					
Collaborative	19	29	7 (41.1)	2	Indiv.	0	13	33	11	19	5	8	49
	(17.9%)	(37.1)			Collab.	13		5					
Total	106	78	17 (100)	3	Indiv.	0	6	2	8	8	0	1	10
	(100%)	(100)			Collab.	6		0					
Sum						33		105		48		15	201

Based on Table 1, instructors employed significantly more collaborative activities to access higher levels of cognitive learning. Table 2 shows that, while multiple-choice is used more for Level 1 assessments, the others are more evenly distributed, $\chi^2(6, N=201)=17.449, p=.008$. Figure 1, below, illustrates the average times (in seconds) spent using different interactions. A one-way ANOVA analysis shows a significant interaction between activity type and duration, $F(4, 118)=9.71, p<.01$.

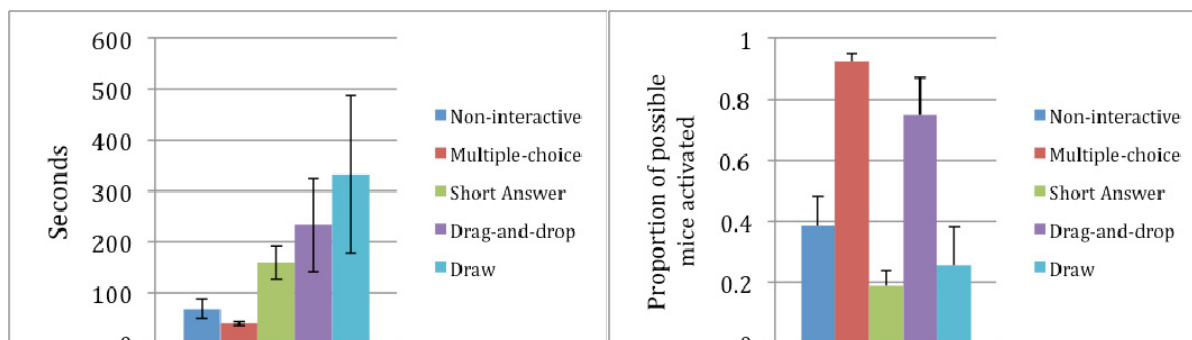


Figure 1. Average time spent using different activities. Error bars represent standard error.
 Figure 2. The proportion of mice activated out of the total number available in the class, across different activities. Error bars represent standard error.

One unexpected finding from this analysis is that multiple-choice activities are not significantly longer than non-interactive activities. Non-interactive slides could be instructional material where the instructor is teaching and activating students for various reasons during instruction. Figure 6 shows the proportion of students activated across activity types. A one-way ANOVA analysis shows a significant interaction between activity type and proportion of mice activated, $F(4, 118)=47.316, p<.01$.

Results and Conclusion

Instructors designed far more low-level activities. For those activities, they used designs meant for individual assessment. For higher-level forms of assessment, on the contrary, they tended to create multiuser activities. This begs the design of more multiuser formative assessments. In classes where the system was used, they used it frequently and spent significantly more time on multiuser activities than on individualistic activities. Instructors were not as bothered by visual clutter as much as we expected. Interestingly, non-interactive slides had a non-negligible amount of students activated on them. One interpretation of this is that instructors are creating collaborative activities that are not supported by existing features.

References

Black, P. and Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. Phi Delta Kappan, 80 (2): 139-148. <http://www.pdkintl.org/kappan/kbla9810.htm>
 Bloom, B., Englehart, M. Furst, E., Hill, W., Krathwohl, D. (1956). Taxonomy of educational objectives: The classification of educational goals: Cognitive domain. Longmans, Green.
 Moraveji, N., Kim, T., Ge, J., Pawar, U.S., Mulcahy, K., Inkpen, K. (2008). Mischief: supporting remote teaching in developing regions. In Proceedings of ACM CHI’08.

Patterns of Collaborative Convergence in a Scenario-based Multi-user Virtual Environment

Shannon Kennedy-Clark, Kate Thompson, Centre for Computer Supported Learning and Cognition, Faculty of Education and Social Work, The University of Sydney, Sydney, Australia,
Email: shannon.kennedy-clark@sydney.edu.au, kate.thompson@sydney.edu.au

Abstract: This paper presents the findings of a study that investigated how participants collaboratively solved a scientific inquiry problem in a virtual environment. 12 participants worked in pairs to complete either a structured or unstructured problem. The study used a modified version of the Decision Function Coding System to identify decision making processes. The results of the study indicate that those in the structured group showed a more direct route to convergence on a goal.

Introduction

This paper presents the findings of a study that investigated how participants collaboratively converge on a goal in *Virtual Singapura*, a scenario-based multi-user virtual environment (MUVE) designed for scientific inquiry learning.

Background

A number of authors have investigated collaboration in science education (Jeong & Chi, 2007; Oliveira & Sadler, 2007; Suthers & Hundhausen, 2003)). These authors identify convergence as the main advantage of a collaborative learning environment. Convergence occurs when students engage in collaborative inquiry learning and mutually construct understanding of the phenomenon (Roschelle, 1992). Jeong and Chi (2007) analyzed conversations and determined that the convergence in their study could be attributed to collaborative interaction. These authors say that convergence is due to the shared input of ideas, and exemplified in the materials produced by the students. They also found that a modest amount of convergence is typical in an unstructured, naturalistic collaborative learning situation. These findings are confirmed by Kapur and Kinzer (2009), who found that participants in an unstructured activity showed more feedback loops and more random pathways to convergence than those in a structured activity. Thus in our study, less convergence is expected for students randomly allocated to unstructured dyads compared to dyads allocated to the structured problem solving task.

Research Design

Participants

This study recorded the in world actions of 12 university students (seven females and five males). Eight of the students were undergraduate education students and four were postgraduates.

Materials

The study used *Virtual Singapura* as the problem solving platform. *Virtual Singapura* is a scenario-based multi-user virtual environment (MUVE) that presents users with a series of inquiry problems relating to disease epidemics in 19th Century Singapore (Kennedy-Clark, Jacobson, & Reimann, 2010). The participants were provided with a paper-based activity that focused on reducing a cholera epidemic in 19th Century Singapore. There were two versions of the activity, one version provided participants with a structured or guided inquiry activity. The second version was unstructured and did not guide the participants through the activity.

Data Collection

The participants completed their in world activity in pairs. The activity took approximately 40 minutes to complete, which included the completion of a virtual activity and a survey. The participants were recorded using *Camstasia* screen capture software.

Data Analysis

The recordings provided three sources of information audio, visual and screen shots. The audio transcriptions were transcribed and coded according to a modified version of the Decision Function Coding System (DFCS) (Poole & Holmes, 1995). We selected DFCS as it allowed for problem definition, orientation and solution development. The resulting coding system has seven main categories and five sub categories. We also selected this coding system as we have used it before to analyze chat data, so this research is building on existing work (Reimann, Frerejean, & Thompson, 2009). The data were then manually tracked to identify the relationships

between the coded items. This did not identify the role of the speaker, but focused on identifying patterns in the decision making processes.

Results

The results of the study indicate that the structured groups (Groups 1, 3 and 5) showed a more direct route in their convergence to arriving at a decision. Two of the unstructured groups (Group 2 and 4), as was predicted, showed more random routes and less convergence and ultimately failed to arrive at a conclusion. Group 6, which was an unstructured group, proved to be an exception in their problem solving process; however, Group 6 was composed of two PhD students both of whom are conducting research in problem solving and inquiry. Figures 1 and 2 provide an example of the patterns of decision making.

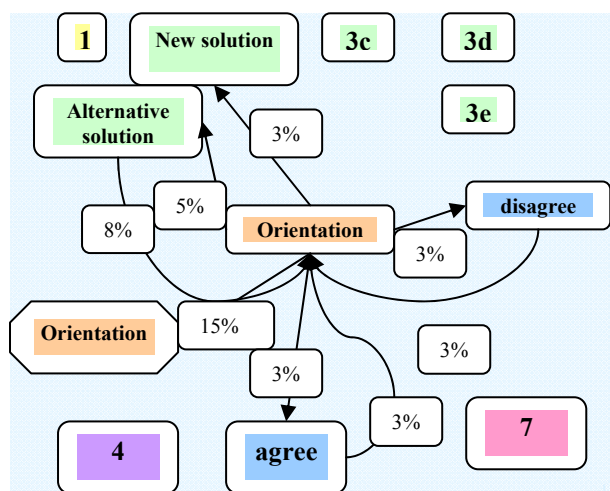


Figure 1. Group 3 Decision Making Processes.

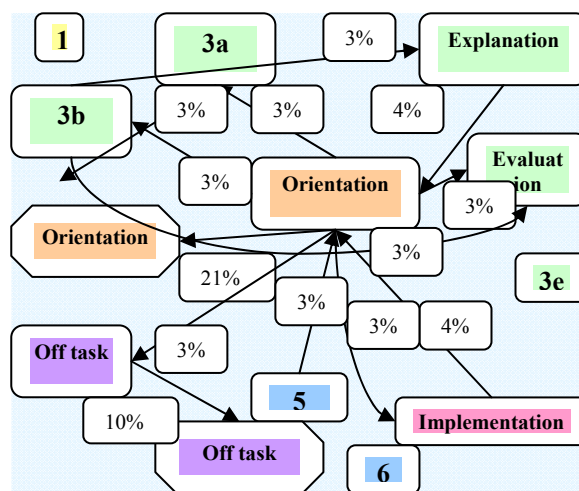


Figure 2. Group 4 Decision Making Processes.

Conclusions

This paper presents the initial analysis of collaborative problems solving in a scenario-based MUVE. The results do indicate that participants in the structured activity showed a more direct route to arriving at a conclusion. The data were coded manually and while patterns do emerge, the next stage is to prepare the data in order to apply process mining techniques to extract patterns in the strategies that students used in solving problems.

References

- Jeong, H., & Chi, M. T. H. (2007). Knowledge convergence and collaborative learning. *Instructional Science*, 35, 287-315.
- Kapur, M., & Kinzer, C. K. (2009). Productive Failure in CSCL Groups. *International Journal of Computer-Supported Learning*, 4(1), 21-46.
- Kennedy-Clark, S., Jacobson, M. J., & Reimann, P. (2010). *Scenario-Based Multi-User Virtual Environments: Productive failure and the impact of structure on learning*. Paper presented at the In Sustaining TEL: From innovation to learning and practice. EC-TEL 2010, Barcelona, 402-407.
- Oliveira, A. W., & Sadler, T. D. (2007). Interactive patterns and conceptual convergence during student collaborations in science [Electronic Version]. *Journal of Research in Science Teaching, Early View: DOI 05/11/2007*. Retrieved 03/12/2007.
- Poole, M. S., & Holmes, M. E. (1995). Decision Development in Computer/Assisted Group Decision Making. *Human Communication Research*, 22(1), 90-127.
- Reimann, P., Frerejean, J., & Thompson, K. (2009). *Using Process Mining to Identify Models of Group Decision Making in Chat Data*. Paper presented at the Computer Supported Collaborative Learning Practices, CSCL 2009, Rhodes, Greece, 98-107.
- Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *The Journal of the Learning Sciences*, 2(3), 235-276.
- Suthers, D. D., & Hundhausen, C., D. (2003). An experimental study of the effects of representational guidance on collaborative learning processes. *Journal of the Learning Sciences*, 12(2), 183-218.

Acknowledgments

The authors would like to acknowledge Singapore Learning Sciences Laboratory and Nanyang Technological University for their ongoing support in the use of *Virtual Singapura*.

Diagnosable Concept Map toward Group Formation and Peer Help

Tsukasa Hirashima, Kazuya Yamasaki, Hiroyuki Fukuda, Hideo Funaoui, Learning Engineering Lab. Information Engineering, Hiroshima University, 1-4-1, Kagamiyama Higashi-Hiroshima Hiroshima, JAPAN
Email: tsukasa@isl.hiroshima-u.ac.jp, yamasaki@isl.hiroshima-u.ac.jp, fukuda@isl.hiroshima-u.ac.jp, funaoui@isl.hiroshima-u.ac.jp

Abstract: In this paper, we propose a framework of "kit-build concept map" as diagnosable concept map toward realization of dynamic group formation and peer help. In the framework, learners build concept maps by combining the provided components. Since such concept maps are composed of the same components, it is possible to diagnose them automatically by comparing within each other or ideal one. In this paper, implementations of a building environment of kit-build concept map and diagnosis of the maps are also briefly introduced.

Introduction

It is widely accepted that concept maps can help students to externalize their knowledge or ideas. Since externalizing their knowledge or ideas of each other and sharing them are a promising approach to promote collaborative learning. Several learning environments have adopted the phase where learners could construct concept maps for a learning topic or their ideas [Stahl 2010]. The concept maps are usually used as materials or opportunities to promote the collaborative activity of learners. Such maps, however, also include very useful information to support their collaborative learning more actively. For example, when learners construct individual map for a learning topic, each map describes about each learner's understanding and misunderstanding. Therefore, it is possible to realize dynamic formation of a group or selection of a helpful peer [Isotani 2009] by finding good combinations of learners based on the results of diagnosis of the maps.

In this paper, we have proposed "kit-build concept map" as a practical approach to realize computer-based diagnosis of concept maps. In the framework of kit-build concept map, learners build concept maps by combining provided components. Since the concept maps are composed of the same components, it is possible to diagnose them automatically by comparing within each other or ideal one. Each map is characterized by some differences. Besides, by piling up the several concept maps, an overlay map that describes the understanding of a learner group can be generated. These maps and the results of the diagnosis are useful to provide with effective information to support collaborative learning from the viewpoint of group formation and peer help. In this paper, implementations of a building environment of kit-build concept map and diagnosis function of the maps are also described.

Framework of Kit-Build Concept Map

In the framework of kit-build concept map, there are four main phases such as; 1) goal map built by teachers, 2) learner map built by learners, 3) comparison of several maps by system, 4) modification of maps by the teachers or learners. Figure 1 shows a simple example of a goal map representing "physical state of matter" in science learning. In this map, "Gas" or "Solid" corresponds to a node word and "deposition" corresponds to a link word. A set of components (we call them as "kits") is generated by decomposing the goal map, as shown in Figure 2. A learner can build a learner map by composing the kits. Figure 3 shows an example of a learner map. Since the learner map is composed of the same kits corresponding to the goal map, the differences between them can easily be detected. In this case, the learner map lacks "deposition" link and includes misconnected "condensation". These differences suggest incomplete portions of understanding of a learner. By overlaying the learner maps, a map describing incomplete portions of understanding of a learner group can be generated. We call such map as "overlay map". Figure 4 shows an overlay map where a link connected by many learners is marked with bold line, such as "melting". A thin line such as "deposition" means that few learner's maps include the link.

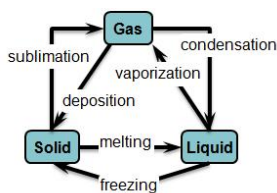


Figure 1. Goal Map.

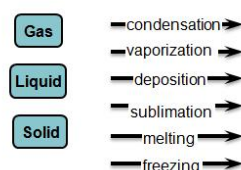


Figure 2. A Set of Kits.

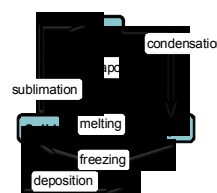


Figure 3. Learner's Map.

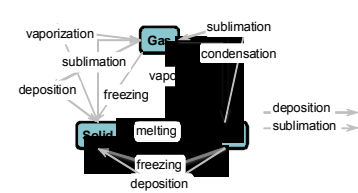


Figure 4. Overlay Map.

Based on these results, it is possible to support collaborative learning from the viewpoint of group formation and peer help. For example, a learner group should be formed so that the overlay map of the group

may include all correct links. The overlay map also indicates the weak points of the understanding of the group. Such information is useful to guide collaborative correction of their maps. Based on the information, it is also possible to find adequate peer to support a learner to correct mistakes in his/her map.

We have already implemented editors of goal map and learner map, and analyzer of kit-build concept map. In the next section, implementation of the editors and analyzer are briefly introduced. Design and implementation of collaborative learning based on the kit-build concept map is the next step of this research.

Implementation

We have developed a system based on the framework of kit-build concept map. The system is called as CmapSystem. It is a web application with three client systems (GoalMapEditor, LearnMapEditor and CmapAnalyzer) and a server system (CmapDB). Both GoalMapEditor and LearnMapEditor have been implemented by Java. Interface of GoalMapEditor is shown in Figure 5. CmapAnalyzer has functions to gather learner's maps, build overlay map and visualize the differences between maps. CmapAnalyzer was implemented by Flash. CmapDB has a function to store and share maps. This system was developed by Ruby on Rails and MySQL. Interface of CmapAnalyzer is shown in Figure 6. Here, only Japanese versions of these systems have been implemented, the words in figures are translated to English.

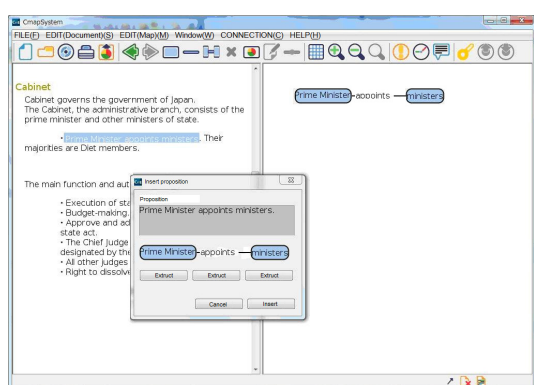


Figure 5. GoalMapEditor.

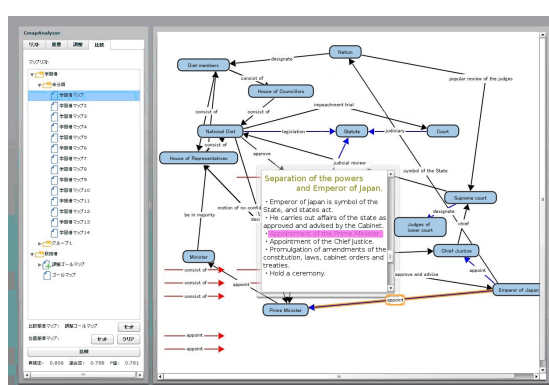


Figure 6. CmapAnalyzer.

Discussion

In usual concept mapping, a learner makes the components by him/herself and organizes them as a concept map. In contrast, a learner is requested to use given components and only to organize them in kit-build concept mapping. Therefore, a learner can focus on the organizing process of the components but misses the activity to make the components. In order to apply kit-build concept map adequately, it is necessary to estimate influence of the differences. There is a similar discussion in note-taking activity that is composed of (1) selecting information, (2) building internal connections and (3) building external connections. Kit-Build concept mapping is corresponding to building internal connections. In the process of building internal connections, selected information from a learning material or lecture is organized as a coherent structure. Several investigations [Kiewra 1991, Armbruster 2000] have suggested that building internal connections is the most influence for learning activity of note-taking and it is better to promote a learner focus on the internal connections by providing selected information by omitting the selection process. Examination of the differences in learning effects between kit-build and scratch-build concept map is our important future work.

Conclusion

In this paper, we propose a framework of "kit-build concept map" as diagnosable concept map toward realization of dynamic group formation and peer help. We have already built a learning environment where learners can make concept maps and they are diagnosed automatically. In the next step of our research, we would design the methods for dynamic group formation and peer help based on the diagnosis and try to practically use them.

References

- Stahl, G. (2010) Guiding group cognition in CSCL, I. J. CSCL 5(3): 255-258.
- Isotani S. A. Inaba, M. Ikeda, R. Mizoguchi (2009) An ontology engineering approach to the realization of theory-driven group formation. I. J. CSCL 4(4): 445-478.
- Armbruster, B. B. (2000) Taking Notes from Lectures. In R. F. FLIPPO and D. C. CAVERLY(Eds.), Handbook of College Reading and Study Strategy Research. Lawrence Erlbaum Associates, NJ, pp. 175-199
- Kiewra, K. A. (1991) Aids to Lecture Learning. Educational Psychologist, 26(1): 37-53

OASIS: Designing CSCL to Support Argumentation

Jingyan Lu, Nancy Law, Liping Deng, Yeung Lee, Faculty of Education, Pokfulam Road, The University of Hong Kong, Hong Kong

Email: jingyan@hku.hk, nlaw@hku.hk, liping.deng@gmail.com, yeunglee@hkucc.hku.hk

Abstract: Computer-supported collaborative learning (CSCL) environments can support inquiry learning by providing argumentation tools. This paper introduces OASIS (Online Annotation and Argumentation Support for Inquiry System) developed to support both cognitive and social processes of argumentation with its visual representation, communication, and management tools.

Introduction

Computer tools can scaffold social and cognitive processes of argumentation by providing opportunities for elaborating, explaining and sharing; by supporting constructing and co-constructing; and by helping students keep track and reflect on their ideas (Andriessen, 2006). This paper introduces an ongoing research project that has developed OASIS (Online Annotation and Argumentation Support for Inquiry System), a theory-driven and pedagogically-guided web-based learning tool, to support communication, argument representation, and argumentation management. OASIS consists of two major parts: 1) a browser-based application on Firefox that enables users to create online annotation for the purpose of collaborative learning (Figure 1) and 2) a website where users can access, organize, manage, and reflect on their learning activities (Figure 2).

Argumentation Representation and Communication

Developing argumentation skills require basic skills such as reading and writing. Highlighting facilitate learners reading argumentatively by visualizing and attending to arguments. In the course of reading, highlighting can draw attention to important points, provide a set of markings for later reference, and help extract structure from the text when re-reading the article (O'Hara & Sellen, 1997). In OASIS, the highlighter tool is designed with different colors, which can assist students construct and compare different perspectives in argumentation.

When doing highlighting, students are prompted to choose from a list of tags that can be either provided by teachers (Task tags) or defined by themselves (My tags). *Tags* can be an external representation of how learners make sense out of the reading and how they organize the knowledge (Hong, Chi, Budiu, Pirolli, & Nelson, 2008). As such, highlighting does not just involve marking the important points, but also a purposeful tagging process that can promote and assist students identify and analyze positions, recognize multiple perspectives and supporting evidence, and construct their own argument. The sticky notes feature can further assist critical reading and *elaboration* on the part of learners. Similar to tagging, the sticky notes come hand-in-hand with highlights; yet it could be used in a more flexible way to assist understanding, analyzing, and thinking. The sticky notes feature provides an easy way to capture their thoughts, opinions, and questions and embed them in the context of source information.

OASIS is a social annotation tool in which way it enables annotating collaboratively on the same webpage, sharing the annotated pages among group members, and communicating via sticky notes. As shown in Figure 1, students can share their annotated work within a group and communicate with group members via sticky notes.

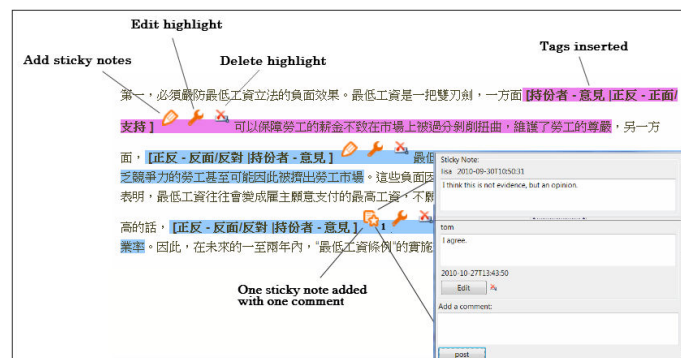


Figure 1. Screenshot of a Webpage Annotated by OASIS.

Management Features

OASIS also has a website (See Figure 2) that allows students to view, organize, manage, and synthesize their annotation. All annotation data are saved in a database and can be available through web server. My collection saves all the web pages and the annotations made on each one. In “My tags” section, students can create new tags, edit the tags created before, or delete them. Another useful feature is to view all the highlights added with a specific tag. In the area of “My groups”, a list of groups a student belongs to will be shown. “My report” enables users to view and export the annotations. He can also export the report as an Excel file and save it for further edit.

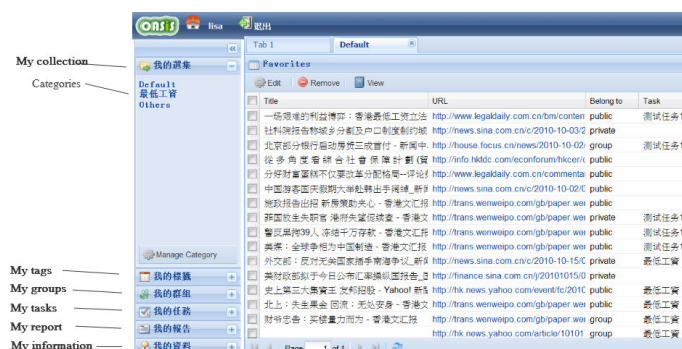


Figure 2. Screenshot of OASIS Website.

OASIS provides a set of tools for teachers to create, monitor, and manage learning tasks and group activities. Teachers can provide tags to scaffold student critical reading. They can create relevant tags based on the learning objectives, the content and nature of the source materials, and assign the tags to the task. Additionally, OASIS allows teachers to monitor students' learning progress. The system can generate statistical reports of students' performance including total number of highlights made, self-defined tags, and sticky notes created by each student in a specific task.

Implication of OASIS Research and Application

Driven by argumentation theories and pedagogical needs, OASIS is designed to support inquiry processes with its visual representation, communication, and management tools. Students can annotate, tag, and share their opinions while reading. They can also organize, reflect, and regulate their inquiry task on the website. OASIS also supports teacher monitor individual, group, and whole class work. It also affords teachers flexibility to create tags so as to support reading argumentatively according to the nature of the task and students' level of ability. More than just a learning tool, OASIS is a research tool through which researchers can study students' cognitive and social behaviors. For instance, it can be researched on if and how different types of annotation representation affect reading and writing arguments; how students argue collaboratively on OASIS with the support of sticky notes; how students manage, reflect, and regulate their inquiry project with the support of OASIS management tools.

References

- Andriessen, J. (2006). Collaboration in Computer Conferencing. In A. M. O'Donnell, C. E. Hmelo-Silver & G. Erkens (Eds.), *Collaborative learning, reasoning, and technology*. (pp. 197-231). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.
- Hong, L., Chi, E. H., Budiu, R., Pirolli, P., & Nelson, L. (2008). SparTag.us: A low cost tagging system for foraging of web content. In *Proceedings of the working conference on advanced visual interfaces* (pp. 65-72). ACM.
- O'Hara, K., & Sellen, A. (1997). A comparison of reading paper and on-line documents *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 335-342). Atlanta, Georgia: ACM.

Acknowledgments

This research is funded by General Research Fund (GRF) from Hong Kong government to Dr. Jingyan Lu. We would like to thank Mr. Xu Zhen for his technical assistance. We would also like to thank our colleagues at the Centre for Information Technology in Education (CITE): Dr. Yeung Lee, Mr Andy Chan, and Mr Murphy Wong for their suggestions to OASIS design and development.

SECI-driven Problem-based Learning for Cultivating Technological Pedagogical Content Knowledge

Meng Yew Tee, Shuh Shing Lee, Faculty of Education, University of Malaya, Malaysia
Email: mytee22@yahoo.com, lshuhshing@yahoo.com

Abstract: This design-based research explored how an problem-based learning (PBL) approach guided by the SECI framework (socialization, externalization, combination, internalization)—with the support of collaborative technologies such as wiki—can help in-service teachers cultivate technological pedagogical content knowledge (TPCK). Based on the quantitative and qualitative data, teachers showed an increase in TPCK. While the results are promising, further research in different settings is needed.

Introduction

Teachers must learn to think more deliberately about how to use technology to improve teaching and learning—specifically, to critically choose or even design and configure, learn and apply technologies that will best meet the teaching and learning needs within their context. This knowledge is often referred to as technological pedagogical content knowledge, or TPCK (Mishra & Koehler, 2006). Built on Shulman's (1986) framework, Mishra and Koehler (2006) suggested that good teaching with technology requires a nuanced understanding of the mutually reinforcing relationships between all three knowledge bases (technology, pedagogy and content) taken together to develop appropriate, context specific strategies and practices. In this paper, we report on the first cycle of a design-based research (Edelson, 2002) exploring an approach to help teachers develop such a knowledge-base.

Design Framework

To cultivate TPCK, the basic idea is to create opportunities for teachers to focus on a problem of practice, and then seek ways to critically choose and use technology to address the problem. Despite learning about technology during this process, they also learn “how to learn” about technology and “how to think” about technology that is most appropriate to the situation they are in, particularly to engage students towards intended learning outcomes (Koehler & Mishra, 2005; Tee & Karney, 2010).

Building on this thinking, a problem-based learning approach (Bransford and Steins, 2002) guided by the SECI framework (Tee & Karney, 2010; Nonaka, Toyama, & Byosiére, 2001) – with the support of collaborative technologies such as wiki – was used as a basis for the design of a semester-long course on teaching and learning with technology for in-service teachers. Activities were designed to enable knowledge sharing, construction and utilization through socialization, externalization, combination and internalization. The overall condition, or *ba* as Nonaka calls it, was designed to energize the knowledge sharing and cultivating activities by providing enabling conditions of autonomy, fluctuation and creative chaos, redundancy, requisite variety, and trust and commitment.

In practice, the first 4-week segment was to give students time to identify and define the problems they were facing in real life. The teachers then worked in teams based on the specific problems they chose to own and work on. The second 4-week segment was for the teams to consider different solutions, propose and select a solution. The third 4-week segment was for each group to implement the selected solution in a pilot or full-blown situation, and subject it to further evaluation. The fourth and final 2-week segment was for students to present and discuss the process and outcome of the entire learning cycle. Each class session was used to discuss findings and suggest and justify ways forward. Each group was required to chronicle their on-going experience on a Wikispace page. In addition, they were also requested to write a 2- to 3-page learning reflection every four weeks on what they have learnt during the process.

Discussion of Findings

The discussion will revolve around Group Beemer because they left a more salient data trail. The first research question is: Can iPBL help in-service teachers cultivate TPCK? A self-progress survey initially developed by Schmidt et al (2009) was improvised to address this question. Using repeated measures t-test, overall statistics (mean prior and mean after the course) for the whole class (N=24) showed significant differences ranging from 0.27 to 1.39, and relatively large effect sizes ranging from .73 to 1.75 (Tee & Lee, 2011). The mean differences for Group Beemer (see Table 1) also showed positive progress in the teachers' TPCK.

The second research question is: If yes to the first question, how? If no to the first question, why not? Group Beemer has 5 members (with pseudonyms of B1, B2, B3, B4 and B5). Group Beemer identified a real-world problem revolving around B1's Year 9 students who were struggling with learning Bahasa Malaysia, or

BM (Malay Language). This happens to be the national language, but many of B1's students did not seem very committed to learning the language.

Initially, the teachers blamed the students. Then, through a series of discussions and exploration of different ways to solve the problem, they began to focus more on what they could do as teachers. And towards the mid-semester, the teachers became more focused on using learning activities to help students attain desired depth of understanding. As they progressed through this experience, they came to realize that technology in itself is not likely to improve learning or bad teaching practices. The following reflection by B2 encapsulates their transformation:

At the beginning we were not very clear about the use of technology basically because we were thinking that technology by itself was an excellent tool to use in teaching, but as the class progressed we realized that we had to focus first on the analysis of our situation and choose the right technology only after doing the whole analysis of the teaching and learning scenario. By learning from the other groups as well, we realized that may be some technological tools that worked excellent with a group of students may not work the same way with others.

Table 1: Summary statistics of teachers' beliefs in using technology for teaching – Group Beemer (N=5).

	Mean prior	Mean after	Mean difference
TK	3.25	3.58	0.33
PK	3.22	3.81	0.59
CK	2.58	3.00	0.42
TCK	2.50	3.25	0.75
TPK	3.15	4.10	0.95
PCK	2.50	3.00	0.50
TPCK	2.58	3.75	1.17

Conclusion

What has happened here, as a precursor to learning to choose and use technology, the SECI-based PBL process had opened up opportunities for the teachers to re-evaluate their teaching practices and to rethink the nature of the subject that they teach, and how technology might play a role to supporting the learning of the subject.

Much of the class was designed with the intention to create a conducive milieu to stimulate SECI, through enabling autonomy, fluctuation and creative chaos, trust and care (Tee & Karney, 2010). Socialization and externalization largely manifested in the form of class discussions, occasional online discussions and out-of-class group discussions. Both externalization and combination can be seen in the wiki-based ebook project and higher-stake presentations at the end of the course. Internalization was stimulated in the implementation and reflections in class, and reflections they were writing for the course. A large part of class time was used to encourage students to present where they were at and more importantly justify their diagnosis of their situation and justify their way forward. While the results are promising, similar research in different settings is needed.

References

- Bransford, J. D., & Stein, B. S. (2002). *Ideal problem solver* (2nd ed.). New York: W.H Freeman and Company.
- Edelson, D. C. (2002). Design research: What we learn when we engage in design. *Journal of the Learning Sciences, 11*(1), 105-122.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.
- Nonaka, I., Toyama, R. & Byosiere, P. (2001). A theory of organizational knowledge creation: Understanding the dynamic process of creating knowledge. In M. Dierkes, A.B. Antal, J. Child & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 491-517). Oxford: Oxford University Press.
- Schmidt, D., Baran, E., Thompson, A., Koehler, M.J., Mishra, P., & Shin, T. (2009). Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice Teachers. *Journal of Research on Technology in Education, 42* (2), 123-149.
- Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.
- Tee, M.Y., & Karney, D. (2010). Sharing and cultivating tacit knowledge in an online learning environment. *International Journal of Computer-Supported Collaborative Learning (ijCSCL), 5*(4), 385-413
- Tee, M. Y. & Lee, S. S. (2011). From socialisation to internalisation: Cultivating technological pedagogical content knowledge through problem-based learning. *Australasian Journal of Educational Technology, 27*(1), 89-104. <http://www.ascilite.org.au/ajet/ajet27/tee.html>

Parcours - Teaching Primary School Children Logical Thinking and Coordination Skills through a Collaborative Smart Table Game

Patrick Dohrmann, Niels Pinkwart, Andreas Rausch, Alke Jürgens, Tim Warnecke, Department of Informatics, Clausthal University of Technology, Julius-Albert-Str.4, 38678 Clausthal-Zellerfeld, Germany
Email: Patrick.Dohrmann@tu-clausthal.de, Niels.Pinkwart@tu-clausthal.de, Andreas.Rausch@tu-clausthal.de, juergens37@kabelmail.de, Tim.Warnecke@tu-clausthal.de

Abstract: Today, typical classrooms are still equipped with blackboards, chalk and sometimes overhead projectors. Technology-enriched rooms can often only be found in school libraries or computer pools where students can research topics on the WWW or use other specific computer applications. In this paper, we present the design of an educational game called “Parcours”, developed for the interactive SMART table. This game, installed on a tabletop that is located within a classroom, is designed to teach primary school children collaboration and coordination skills as well as logical thinking.

Introduction

Today, technology is getting increasingly ubiquitous, even for children at younger ages. Many devices such as interactive cell phones, game consoles or PCs are widespread and children often use them for a variety of purposes, including gaming. Device manufacturers as well as educational practitioners and researchers have tried to include educational games into their portfolio. Regrettably, many existing educational games can only be played in an unsupervised manner, are rather disconnected from education in schools and are single-user based or competitive (rather than truly collaborative). A number of studies has indicated that collaboration can promote children’s learning (e.g., Webb & Palincsar, 1996; Johnson & Johnson, 1990).

The SMART Company regularly starts application contests in which ideas (and prototypes) for innovative collaborative educational games for tabletop devices are invited. In this paper, we present the design and of the 2010 contest winner, the “Parcours” game. Exploiting the benefits of the table top device, this cooperative and co-constructive game is designed to teach primary school children coordination as well as logical thinking skills.

State-of-Art

Educational tools using large interactive displays have gained currency in recent years. The StoryTable application (Cappelletti, Gelmini, Pianesi, Rossi & Zancanaro, 2004) enforced co-operation during story-telling activities, and studies conducted with this system showed that cooperative storytelling can increase the level of engagement of less motivated children without affecting the involvement of the more active ones. Harris, Rick, Bonnett, Yuill, Fleck, Marshall & Rogers (2009) have described a study with the OurSpace application, a groupware tool for solving seat assignment tasks. A result of this study was that multi touch displays reduced group conversations about turn-taking activities and increased task-focused discussions (as compared to single touch interfaces).

In summary, research results indicate that multi touch applications specifically targeted for CSCL are not only technically feasible but also potentially valuable, since they combine intuitive interaction concepts with new face-to-face cooperation mechanisms, leading to novel CSCL application areas, particularly within classrooms. In this paper, we describe the design of “Parcours”, a co-constructive application which, compared to the existing research results as discussed in this section, is unique in its combination of target group (primary school), learning goals (coordination and logical thinking) and group activity type (collaborative game).

Parcours: Purpose and Design

While many educational games focus on specific cognitive educational objectives like improving mathematical, language or memorizing skills, a discussion with a pedagogue spawned the idea to design a collaborative educational game that focuses on teaching *logical thinking* and *coordination skills*. These skills are important for everyday life and child development, yet there is typically no dedicated school subject for them. The design goals of Parcours include that the children of the age group 5-10 should be able to intuitively understand the game, coordinate themselves to win, and enjoy the game.

Basic Game Concepts and Their Relation to the Learning Goals

Parcours is a bridge builder game. It provides a rasterized gaming area where the players have to build a path from a starting point to a goal point by using certain tiles, surrounding the gaming area, in order to help a playing figure across the map, winning the game. Figure 1 depicts the user interface of the game (one of four

available visual themes) and shows that the game can be operated from all sides of the tabletop display. There are two main actions that can be done in the game at the same time: building the path and moving the player.

A small playing figure can be moved across a built path by touching the arrow buttons, thus maneuvering the figure in the direction the arrows are indicating. The path building process is complicated by different obstacles like rocks and ditches: here, the players have to build a path either around them or across them using special tiles. The game features ten different difficulty levels, differing in the amount of obstacles on the screen.

All tiles in the game can be dragged intuitively onto the gaming area by touching and dragging them. They can also be rotated by using at least two fingers, making a rotation movement. All tiles are slightly larger than the raster of the playing field and can be dropped into the gaming area with a “minimizing” gesture.

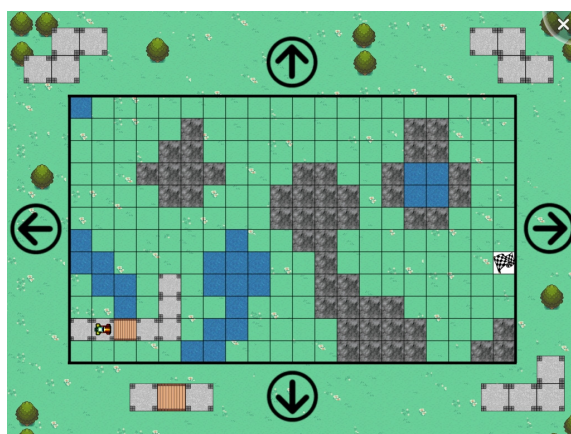


Figure 1. The Game Parcours.

The main opportunity to learn coordination skills is connected to the use of the tiles surrounding the gaming area. The players have to cooperate and agree concerning which tiles to use next, then choose them and pass them to other players around the table, who will then drop them down. Furthermore, they have to coordinate themselves and to cooperate while using the special tiles. Another feature supporting coordination and cooperation is the movement of the figure because the arrow buttons are distributed around the area, forcing the players to discuss the next steps and to work together to allow the playing figure to reach the goal.

Furthermore, the players are forced to think logically because they have to choose the tiles they will use wisely. If there are no tiles left to finish a path, they will lose the game.

Pilot Tests and Teacher's Feedback

We tested the game in a primary school. Children who played the game confirmed the simple and intuitive handling of the game. As expected, the children were discussing about the next steps they wanted to do and helped each other using the special tiles, which require cooperation and coordination.

We also interviewed the pedagogue who observed the children playing Parcours. She stated that she believes that this kind of game can be very useful for multiple school subjects. While the game was intended to teach coordination and logical thinking, the teacher also discovered other possible beneficial side effects in learning, e.g. language and geometry skills. The teacher also stated that she believes the concept of learning with a multitouch screen is very enjoyable and has potential to keep the school children excited and motivated.

In summary, while not constituting solid evidence, first tests of Parcours in school suggest that this game has the potential to help primary school children learn a set of diverse skills, including logical thinking and coordination. The next steps on our research agenda include an extended empirical evaluation of the system.

References

- Cappelletti, A., Gelmini, G., Pianesi, F., Rossi, F., and Zancanaro, M. 2004. Enforcing Cooperative Storytelling: First Studies. In *Proceedings of ICALT*. IEEE Computer Society, Washington, DC, 281-285.
- Harris, A., Rick, J., Bonnett, V., Yuill, N., Fleck, R., Marshall, P., and Rogers, Y. 2009. Around the table: are multiple-touch surfaces better than single-touch for children's collaborative interactions? In *Proceedings of CSCL*, pp. 335-344.
- Johnson, D. W., & Johnson, R. T. (1990). Co-operative learning and achievement. In S. Sharan (Ed.), *Co-operative learning: Theory and research* (p. 23-37). New York, NY (USA): Praeger.
- Webb, N. M., & Palincsar, A.S. (1996). Group processes in the classroom. In D.C. Berliner & C. Calfee (Eds.), *Handbook of Educational Psychology* (pp. 841-873). New York: Simon & Schuster Macmillan.

Dialogic Framework for Creative and Collaborative Problem-solving

Deller James Ferreira, Federal University of Goiás, Informatics Institute, Campus II Samambaia-Prédio IMFI-Goiânia-Goiás-Brazil-74001-970, deller@inf.ufg.br

Rupert Wegerif, University of Exeter, Graduate School of Education, St. Luke's Campus - Heavitree Road – Exeter-UK - EX1 2LU, R.B.Wegerif@exeter.ac.uk

Abstract: This work introduces a pedagogical dialogic framework that nourishes creativity during collaborative problem solving. The framework embraces six creative dimensions that allow students' voices to enter in and inter-animate each other in a way which new possibilities emerge. Students are aware with a bigger range of possibilities in a discussion and are able to go deeper into an argument to explore its assumptions and implications.

Introduction

Collaborative and creative problem-solving skills involve more than just following a procedure or the application of a model. It is a complex enterprise that may introduce a considerable amount of uncertainty to students. It's accompanied by associated thinking strategies and requires flexibility. Engaging in collaborative and creative problem-solving is particularly difficult for students. The lack of meta-cognitive knowledge hinders their ability to creatively and collaboratively solve problems. Students rarely build a knowledge base that is sufficiently robust because they underestimate the complexity of new knowledge and generate excessively vague relationships between prior knowledge and new knowledge. External guidance is necessary to remind students to pay attention to specific processes while solving problems. Teaching thinking strategies is of prime importance to boost collaborative and creative problem-solving skills. Wegerif (2010) proposes a dialogic theory of thinking and teaching thinking and creativity, which starts from the metaphor of thinking as dialog. For dialogic theory, learning to think means being pulled out of oneself to take the perspectives of other people and through that engagement in a play of perspectives, to be able to creatively generate new perspectives or ways of seeing and thinking the world (Wegerif, 2010). The dialogic space is a space of ideas that allows students to reflect on ideas and see them from lots of other students' points of view at once. To overcome students' obstacles during collaborative and creative problem solving, we propose a dialogic framework to designing for creative collaborative learning with particular emphasis on distinct ways to explore the dialogic space.

Dialogic Framework for Teaching Thinking Strategies for Creative and Collaborative Problem-solving

Wegerif (2010) proposes a scaffolding approach to teaching thinking as opening, widening and deepening dialogic space. When the teacher promotes the opening of a dialogic space allows many voices to enter in and inter-animate each other in a way which creatively opens up new possibilities. Students are engaged in a widen dialog space when they are better acquainted with the range of positions that are possible and they deepen a debate when they are able to go deeper into a single bit of the argument to explore its assumptions and implications.

Considering as a starting point Wegerif's educational dialogic theory, we develop in this work a pedagogical dialogic framework that embraces six dimensions that allow a dialogic space exploration, widening and deepening it. These dimensions are: immersing, unpacking opportunities, overcoming boundaries, expanding, discovering unpredictable places, and developing.

Immersing in Dialogic Space

This dimension concerns with the enhancement of the analogical and metaphorical thinking. Analogical reasoning is one of the most important problem-solving heuristics. It is related to the transfer of solutions from previously known problems to novel ones and the ability to abstract similarities and apply previous productive experiences to new situations. Analogies and metaphors move students into the unknown. The function of metaphors is to describe a reality outside of reality itself. Metaphors convey attention to something different in order to be able to understand how something was given. Analogies and metaphors transfer us from an old meaning to a new one allowing a different understanding. This dimension is also concerned with the search for information. To be successful at discovery and innovation students should be aware of previous and related work and should be aware of principles and techniques to be applied in the development of their work. The more diverse your knowledge, the more interesting the interconnections. Students widen the dialogic space while jointly search information having an objective in mind and search information for inspiration, detect relevant and irrelevant information, recognize familiar information and cope with new information, reapply techniques and adapt techniques, experience having an open mind and experience having an objective, state goals and brainstorm, adapt hypothesis and make conjectures, explore similarities and differences of a metaphor, and

explore similarities and differences of an analogy.

Unpacking Dialogic Space Opportunities

Students unpack opportunities collaboratively looking for attributes and relationships among concepts and new ideas, and try to organize the information, deepening the dialogic space. They recognize dependence and independence relations, necessary and sufficient conditions, causes and effects, similarities and differences, correspondences and oppositions, class inclusion and exclusion, associations and dissociations, hierarchy ascendant and descendant relations, order and disorder, generalities and specificities, abstract and concrete features, potential and non-potential uses/functions, and examples and counter-examples. This dimension involves the improvement of the ability to explicit what is already there but hidden. It encompasses interplay between abstract and concrete ideas, where example, artifacts or concrete ideas are used to refine abstract ideas. This dimension is also related to the divergent thinking ability elaboration. Elaboration is an important component of the creative process and consists of the who, what, why, and how elements of solution ideas.

Overcoming Dialogic Space Boundaries

Students widen the dialogic space while jointly overcome the dialogic space boundaries situating the ideas in a bigger context, performing contextual shifting. They jointly search for relationships with “neighbor” ideas outside a given context, scope and limitations, and constraints. They perform critical transitions and constraint relaxation to identify key places in the dialogic space where good and bad ideas can be better developed. This dimension is related to an attempt to overcome it and visualize concepts and ideas in an open minded way. Seeing an idea in different contexts and also seeing ideas in a bigger scenario is a way to overcome conceptual barriers. Considering ideas in new contexts is a way of gaining insight about other possible uses and meanings.

Expanding the Dialogic Space

The students widen the dialogic space making together re-combinations and combinations of similar or distinct concepts and ideas, building on other’s ideas, and re-thinking their previous ideas. The students also try to make combinations of possible disparate or unconnected ideas by means of a dialectical synthesis or encapsulating the entire dimension of a new concept. They derive new knowledge on the basis of a lack of similarity between two or more past constructs or elements from domains which are far apart. This dimension entangles constructive interactions among students related to innovative construction of a complex system of ideas. The main premise in this dimension is that unexpected, new arrangements, and other’s interpretations triggers new interpretations and ideas. Previous opinions and concepts are co-constructed and students’ understandings expanded. Students integrate answers from many places in diverse ways, in a process of transcending and exchanging different perspectives and constructing new ideas.

Discovering Unpredictable Places in the Dialogic Space

This dimension capitalizes on often way in which bad ideas become beneficial detours to good ideas. We are considering failure as a key aspect of creativity and thinking of failure as a new opportunity, as a way to forward with it. The exploration of good ideas allows a local exploration of the dialogic space, which leaves unexplored large areas of this space. The exploration of bad ideas pulls the students to new unpredictable places, facilitating a movement to far away areas, which thus overcome the drawbacks of the limited exploration of that good ideas entail. Students widen the dialogic space when turn ideas and concepts in new interpretations, also thinking about misconceptions.

Developing the Dialogic Space

This dimension encompasses the evaluation, critics, and bringing together of ideas. By means of evaluations of ideas students are able to carry out decision making processes based on criteria application and improve ideas considering its bad features. One important aspect of this dimension is that when students evaluate and critique different perspectives and ideas they must be confronted with uncertainty and conceptual conflict. Both are states of disequilibrium that activate a process of conflict resolution and a quest for certainty. Students deepen and widen the dialog space evaluating, comparing, selecting concepts and ideas, considering different alternatives, pointing positive and negative outcomes based in criteria application, starting a search for a more adequate cognitive perspective and reasoning process aiming to resolve conflict and uncertainty.

References

Wegerif, R. (2010). The Role of Dialog in Teaching Thinking in Technology. C.Howe & K. Littleton. (Eds.) *Dialogue and Development*. Routledge, 338-357.

Design Study on Algebra Reform: A GenSing Project

Sarah M. Davis, Suzanne Nelson, David Effendi, Learning Sciences Lab, National Institute of Education, Singapore

Email: sarah.davis@nie.edu.sg, suzanne.nelson@nie.edu.sg, david.effendi@nie.edu.sg

Abstract: This paper reports on classroom-based research created to design and implement an algebra reform curriculum. This paper focuses on the students' pre-assessment and post-assessment data collected during the second year of a continuing design study. Analysis of gains by section revealed that intensity of student gains did not mirror student stream/band placement. A one-way ANOVA showed that the difference in gains between the groups with different levels of implementation fidelity was significant $F(2,207) = 26.61, p \leq 0.05$.

Introduction

This paper reports on classroom-based research created to design and implement an algebra reform curriculum based on the principals of generative design (Stroup, Ares, Hurford, & Lesh, 2007) that incorporates function-based algebra (Kaput, 1995) and is facilitated by the use of a classroom network. Research has shown that the generative function-based approach to teaching algebraic concepts has the potential to improve students' understanding of the structural aspects of introductory algebraic concepts (Stroup, Carmona, & Davis, 2005) and that new classroom-networked technologies provide opportunities to increase student participation and engagement with the topics of instruction (Davis, 2002).

Methods

Research Design - The multi-tiered design study (Kelly, Lesh, & Baek, 2008) focused on students' developing understanding of function-based algebra via Generative Activities in a networked classroom and the teachers' pedagogical practices needed to foster these activities. This paper focuses on the students' pre-assessment and post-assessment data collected during the second year of a continuing design study into Generative Activities in Singapore (GenSing).

Participants - The data for this study was collected at an upper-performing secondary school in Singapore. The participants encompassed all of the 2008 school year, Secondary 1 (12 to 13-year-olds) express-track students ($n = 239$) at the research site. Data was collected from six sections (classes) and each section ranged from 39-41 students. The academic year for the 2008 Secondary 1 students began in January, ending in October, and was divided into four terms. Each Secondary 1 express-track mathematics section was taught by a different teacher and each teacher remained with their assigned section throughout the school year. This provided the opportunity to study six separate teachers and the integrity of pedagogical implementation.

Intervention - The Secondary 1 mathematics scheme of work (scope and sequence) was reorganized to gather all of the algebraic topics covered across the year into two cohesive groupings, one lasting eight weeks and one lasting four weeks. In accordance with generative design principles, the questions and the opportunity for student input are structured to allow for students' individual creativity and exploration of the mathematical topic. The intervention teachers observed model teachings of the activities in their own classrooms with their students, experienced the activities as students in a series of department meetings, and participated in a 2-day workshop. During the 2008 intervention each activity was previewed the week prior to its implementation with the teachers during a planning period. During the activity-preview questioning strategies, possible student responses and ways to use the technology to help foster class interactions were discussed.

Data - For the 2008 implementation, a pre-assessment and post-assessment was created. The research project is iteratively designing a 20-item, algebra assessment to not only assess students' computational ability to manipulate variables but to also evaluate students' conceptual understanding of algebraic topics. The data reported on in this paper reflects the first iteration of the pre-/post-assessment.

Results

For the purposes of analysis, the students' responses to individual items on the pre-assessment and the post-assessment were divided into quantitative and qualitative data segments. The quantitative and qualitative data were analyzed using different methods and this paper will focus on the quantifiable items. For the 28 quantitative items, a paired samples t-test (Table 1) showed a significant difference between pre-assessment and post-assessment results ($t = 21.356, df = 207, p \leq 0.05$).

Table 1: Paired samples statistics.

	Mean	N	Std. Dev.	Std. Error Mean
Pair 1 Post	18.45	210	3.472	.240
Pre	13.09	210	2.808	.194

Comparison of Pre-Test to Post-Test Gains by Sections

The gains were then calculated for each section of the Secondary 1 students to investigate possible classroom effects, and statistically significant differences were found between the sections. We argue that the difference between gains in sections is the result of the integrity of intervention implementation. One section (n=37) had Level 1 implementation integrity with a mean raw gain of 8.22; three sections (n=107) had Level 2 with a mean raw gain of 5.22; and 2 sections (n=66) were at Level 3 with a mean raw gain of 3.83.

To assess if the gains were statistically different across the three levels of implementation, an ANOVA test was carried out. Hake's Gain score (Table 2) was calculated for each student and used as the measure of gain for the ANOVA test. Hake's Gain was chosen to adjust for the "ceiling effect" where students who scored high on the pre-test had less room for gain compared to students who scored lower on the pre-test (and therefore, could potentially inflate the gain scores of students who scored lower on the pre-test). The Level 1 implementation group had a mean Hake's Gain score of 0.57, meaning that on average, students from this group made a 57% gain over what was possible, based on their pre-test score, the means for implementation Level 2 was 0.33 and Level 3 was 0.26.

Table 2: Hake's Gain.

	N	Mean	Std. Dev.	Std. Error	Minimum	Maximum
Level 1	37	.5667	.23273	.03826	.07	.86
Level 2	107	.3347	.21249	.02054	-.50	.76
Level 3	66	.2562	.19135	.02355	-.25	.77
Total	210	.3509	.23416	.01616	-.50	.86

A one-way ANOVA (Table 3) showed that the difference in gains between the groups with different levels of implementation was significant $F(2,207) = 26.61$, $p \leq 0.05$. The effect size was medium ($\eta^2 = 0.45$). Results indicated that integrity of implementation had a medium impact on gain.

References

- Davis, S. M. (2002). Research to industry: Four years of observations in classrooms using a network of handheld devices. In M. Milrad, H. U. Hoppe & Kinshuk (Eds.), *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education* (pp. 31-38). Växjö, Sweden.
- Kaput, J. J. (1995). *A research base supporting long term algebra reform?* Paper presented at the Seventeenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Columbus, OH.
- Kelly, A. E., Lesh, R. A., & Baek, J. Y. (Eds.). (2008). *Handbook of Design Research Methods in Education*. New York: Routledge.
- Stroup, W. M., Ares, N., Hurford, A. C., & Lesh, R. (2007). Diversity by design: The what, why and how of generativity in next-generation classroom networks. *Foundations for the Future in Mathematics Education*. Mahwah, NJ: Lawrence Erlbaum Publishing Company.
- Stroup, W. M., Carmona, L., & Davis, S. M. (2005). Improving on Expectations: Preliminary Results from Using Network-Supported Function-Based Algebra. In S. Wilson (Ed.), *Proceedings of the 27th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. Blacksburg, VA.

Acknowledgments

The research reported on in this paper was funded by the Office of Educational Research at the National Institute of Education, Singapore.

Can Participation and Procrastination in Discussion Forums Predict Project Performance in Computer Science Courses?

Jaebong Yoo, Erin Shaw, Jihie Kim, Information Sciences Institute, University of Southern California
Email: jaebong@isi.edu, shaw@isi.edu, jihie@isi.edu

Abstract: This paper presents an analysis of project grades and discussion forum participation. In a study of 1,593 messages, it is shown that only 13% of the project grades can be explained by forum postings. However, by applying a new metric, Average Posting Time to Deadline, about 27% of the grade can be explained. The strength of the study lies in its use of targeted project-based forums and grades and the new metric

Introduction

Asynchronous discussion forums can encourage collaborative learning and promote discovery-oriented activities. Researchers have sought to understand the relationship between forum participation and achievement by discourse analysis. The most common way of evaluating the effect of forum participation on achievement is to correlate message incidences with course grades (Davies & Graff, 2005). Traditional discussion forum metrics used in quantitative studies include the number of the total messages, initial postings and replies, number of messages read, and response times from previous messages (Palmer, Holt, & Bray, 2008). The results indicate that the relationship between participation and achievement is inconsistent and may depend upon measuring methods. This paper explores the influence of participation on student achievement in a targeted context. First, participation is considered with respect to project-based forums that are used by students to seek answers to questions about the current project. Second, student achievement is considered with respect to project grades. Finally, traditional forum metrics are considered in conjunction with a new metric based message posting times relative to the project due date. This number is referred to as average posting time to deadline, or APTTD. The sections of the paper are laid out as follows. In the following section, the methodology of the study is explained; in the next section, the results of the study are presented; and in the final section there is a concluding discussion.

Methodology

The study took place in the context of an Operating Systems course in the Computer Science Department at the University of Southern California. The same instructor has taught it for the past 15 semesters. The course discussion board consists of “Projects”, “Lectures”, “General Nachos Questions”, “TA Office Hours” and “Humor” forums. For this study, we consider student project grades and participation in corresponding project-related forums only, and not overall forum participation and final grade. In this respect, our approach is distinctly different from other approaches (e.g., Davies & Graff, 2005; Palmer et al., 2008). Participation on the discussion board is optional but can be used to influence a borderline grade at the instructor’s discretion.

Sample

Student data, project grades, and online discussions were collected for three fall semesters of the course. The number of registered students in each semester was 85, 119, and 124, for the years 2006, 2007, and 2008, respectively, and of the 215 students who participated in discussion forums posted 1,593 messages: initial posts (693) and replies (900). Project grades were transformed into normalized scores (Z-score) to avoid potential errors due to variability such as time, instruction, teacher, score, and other factors. For three years, the discussion board was observed to inspect the on-line activities of the participants because the quantity of student posts is a common and usually straightforward measure to gather from learning management system (Bliss & Lawrence, 2009).

A New Metric

We assumed that the longer average posting time to deadline students have, the better performance they have. The average posting time to project p ’s deadline of student s is denoted $APTDD_{ps}$. The $APTDD_{ps}$ is defined as follow:

$$APTDD_{ps} = \left\{ \sum_{p=1}^P \sum_{m=1}^{M_{ps}} \frac{T(end_p) - T(message_{sm})}{T(end_p) - T(start_p)} \cdot \frac{1}{M_{ps}} \right.$$

where $T(end_p)$ is the deadline of project p , $T(start_p)$ is the start date of project p , and $T(message_{sm})$ is the time stamp when student s posts the m -th message on the project p forum of the discussion board.

Results

A Pearson correlation coefficient was computed to assess the relationship between the normalized project grades (Z-score) and the number of initial/reply/total, and APTTD. Table 1 summarizes the results. Overall, there was a highly significant, positive correlation between Z-score and APTTD. This indicates that students who posted messages earlier from the deadline tend to get better grade than others.

Table 1: Inter-correlations between variables among participants.

Correlations	Total posts	Initial posts (IP)	Reply posts (RP)	APTTD	Z-score
Total posts	1	.862** .000	.974** .000	.512** .000	.155* .023
Initial posts (IP)	.862** .000	1	.724** .000	.653** .000	.147* .041
Reply posts (RP)	.974** .000	.724** .000	1	.456** .000	.151* .031
APTTD	.512** .000	.653** .000	.456** .000	1	.307** .000
Z-score	.155* .023	.147* .041	.151* .031	.307** .000	1

$N = 215$; * $p < .05$; ** $p < .01$; Pearson Correlation Sig. (2-tailed).

Multivariate linear regression analysis was conducted with Z-scores as the dependent variable. All other known variables were initially introduced as independent variables in Table 1. The result shows the coefficients of the regression model and their significance. The regression equation model is: $Z - score = -.210 - .096IP + 0.028RP + 1.01APTTD$. An analysis of variance test suggests that the regression model is significant, $F(3, 211) = 8.094$, $p < 0.001$, although the model predicts only 10.3% of the variation on Z-score ($R^2 = 0.103$). When the number of total message is larger than 12, the result indicated the predictor APTTD explained 27% of the variance ($R^2 = 0.27$, $F(3,30) = 3.60$, $p < 0.05$). It was found that the APTTD predicted the Z-score of high participating students 16.7% more than that of all participants (only considering the total posts, ($R^2 = 0.13$, $F(1,32) = 4.59$, $p < 0.05$). The APTTD is highly correlated to forum participation frequency, about 27% of the grade can be explained.

Conclusion

Our results indicate that *average posting time to deadline*, or APTTD, is statistically significant and highly correlated to discussion forum participation frequency. It is also observed that there is a significant, positive correlation between project grades and APTTD. For more accurate assessment, other latent factors should be considered in the future with a semantic-based analysis. Our results may provide hints on best instructional practices such as promoting earlier resolution of project-related questions on the discussion board and preventing rushes.

References

- Bliss, C. and B. Lawrence (2009). "From posts to patterns: A metric to characterize discussion board activity in online courses." *Journal of Asynchronous Learning Networks* 13(2): 15~32.
- Davies, J. and M. Graff (2005). "Performance in e learning: online participation and student grades." *British Journal of Educational Technology* 36(4): 657-663.
- Palmer, S., D. Holt, & S. Bray. (2008). "Does the discussion help? The impact of a formally assessed online discussion on final student results." *British Journal of Educational Technology* 39(5): 847-858.

Acknowledgments

The authors would like to thank USC Senior Lecturer Michael Crowley for his assistance and the members of the PedTek team. This work was funded by the National Science Foundation, under a CCLI and CISE awards [#0618859](#), [#0917328](#).

Enhancing Computer-supported Case-based Learning for Pre-service Teachers: Effects of Hyperlinks to Conceptual Knowledge and Multiple Perspectives

Jan Zottmann, Frank Fischer, LMU Munich, Department of Psychology, Leopoldstr. 13, D-80802 Munich, Germany

Email: jan.zottmann@psy.lmu.de, frank.fischer@psy.lmu.de

Annika Goeze, Josef Schrader, University of Tuebingen, Institute of Educational Science, Muenzgasse 11, D-72070 Tuebingen, Germany

Email: annika.goeze@uni-tuebingen.de, josef.schrader@uni-tuebingen.de

Abstract: Effects of instructional support for pre-service teachers (n=100) learning with digital video cases were investigated in an empirical field study with a 2x2 factorial design during a four-day university course. Hyperlinks to conceptual knowledge and/or multiple perspectives were implemented into a computer-supported learning environment. Analyses of learning processes and outcomes provide evidence that both forms of instructional support could enhance the effectiveness of case-based learning by fostering specific components of the prospective teachers' analytical competency.

Objectives of the Study

The professional competency of teachers is strongly connected to their competency of being able to understand and analyse classroom situations (Schrader, Hohmann, & Hartz, 2010). Analytical competency can be structured into (1) the ability to portray pedagogical situations in a differentiated way, (2) the ability to become immersed in multiple perspectives (especially those of teachers and learners, see Oser & Baeriswyl, 2000), and (3) the ability to apply conceptual knowledge to case information in order to better understand the situation at hand.

Methods of case-based learning are considered to have great potential for promoting analytical and problem-solving abilities in teacher education. This is particularly true for methods utilising authentic cases with the purpose of enabling learners "to explore the complex and messy problems of practice" (Merseeth, 1996, p. 725). Cases implemented to educate learners in analytical skills typically comprise complex and authentic situations that require analysis, problem-solving, and decision making. Recent empirical research, however, has demonstrated that learners do not get the most out of case-based learning without additional instructional support (e.g., Fitzgerald et al., 2009; Moreno & Valdez, 2007).

Cognitive Flexibility Theory (CFT) can be drawn upon as a basis for instructional support that seeks to further flexible knowledge application in different real situations, increase awareness of one's own perspective, and allow for the construction of connections to alternative perspectives (Spiro, Collins, Thota, & Feltovich, 2003). The CFT further recommends the use of hypermedia environments to realize a non-linear, multi-dimensional presentation of contents. As digital video technology allows for the visualisation of dynamic processes, approximating a fuller presentation of complexity to learners, it has been recommended for training in ill-structured domains (Goldman, Pea, Barron, & Derry, 2007) such as teacher education.

Research Questions

The empirical study presented here aimed to answer the following research question: how do hyperlinks to conceptual knowledge, hyperlinks to multiple perspectives, and a combination of them both facilitate the analytical competency among pre-service teachers in a computer-supported case-based learning environment? In addition, collaborative learning processes were investigated to find out if these instructions may help counteract some of the known deficits of case-based learning, i.e. learners tending to get sidetracked instead of analyzing the case in a goal-oriented way, or insufficient immersion of case-based learners who are often unable to adopt alternate perspectives (see Zottmann et al., in press).

We hypothesised for learning processes and outcomes that the availability of conceptual knowledge in the learning environment would have a positive effect on the application of conceptual knowledge, while the availability of multiple perspectives would have a positive effect on immersion.

Methodology

A total of 100 prospective foreign-language teachers (English as a second language) participated in this field study with a 2x2-factorial design, the factors being "conceptual knowledge" and "multiple perspectives". The case-material for the study was recorded in regular English lessons for intermediate learners. Authentic case sequences of up to 15 minutes were implemented in a computer-supported learning environment that was developed for this study based on the ideas of the CFT.

The study was realised as a four-day university course for pre-service teachers. On the first day, these teachers were introduced to case-based learning within the scope of a lecture, before control variables and demographic data were assessed. Subsequently, participants wrote a pre-test case analysis individually without instructional support. For the following four training cases on days two and three, the experimental conditions were realised: the factor “conceptual knowledge” was varied by providing / not providing hyperlinks to short descriptions of various pedagogical models and theories of learning and instruction (Cognitive Apprenticeship being one of them, for instance) that could be applied to the case. The factor “multiple perspectives” was varied by providing / not providing hyperlinks to authentic comments made by the teacher and learners from the video. These comments had been generated from interviews conducted a few weeks after the course took place. Regardless of the experimental condition, learners analysed each training case individually (40 min.) and in groups of three (65 min.). The small group interactions were recorded on video to investigate the learning processes. Learners had to write a post-test case analysis individually without instructional support on day four.

For quantifying the dependent variable analytical competency, a complex coding scheme for the measurement of analytical competency was developed that incorporated its aforementioned three components. ANCOVAs were conducted to examine the effects of instructional support on learning processes and outcomes relating to the acquisition of analytical competency.

Results and Conclusions

Individual learning outcomes show that learners drew on conceptual knowledge more often in their post-test case analyses when hyperlinks to conceptual knowledge were available to them throughout the course, $F(1;95)=10.14$; $p<.01$; partial $\eta^2=.10$. Learners supported with hyperlinks to multiple perspectives adopted teacher and learner perspectives more often in the post-test than participants who did not have this support, $F(1;95)=8.38$; $p<.01$; partial $\eta^2=.08$.

With respect to the learning processes, particularly the hyperlinks to multiple perspectives affected the small group discussions of the cases as they led to an increase of immersion, $F(1;95)=6.05$; $p<.05$; partial $\eta^2=.06$. With respect to sidetracking, however, a significant interaction between the two factors was found, $F(1;95)=5.16$; $p<.05$; partial $\eta^2=.05$. Study participants in the combined condition made fewer case-related statements than learners in any other experimental condition.

In summary, results of this study provide evidence that additional instructional support in the shape of hyperlinks to conceptual knowledge and multiple perspectives embedded in a computer-supported environment can indeed enhance the effectiveness of case-based learning by fostering specific components of analytical competency - a competency that is considered crucial for teachers' professional performance.

References

- Fitzgerald, G., Koury, K., Mitchem, K., Hollingshead, C., Miller, K., Park, M. K., & Tsai, H. (2009). Implementing case-based instruction in higher education through technology: what works best? *Journal of technology and teacher education*, 17(1), 31-63.
- Goldman, R., Pea, R. D., Barron, B., & Derry, S. (Eds.). (2007). *Video research in the learning sciences*. Mahwah, NJ: Erlbaum.
- Merseth, K. K., (1996). Cases and case methods in teacher education. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.) *Handbook of research on teacher education* (2nd ed., pp. 722-744). New York, NY: Macmillan.
- Moreno, R., & Valdez, A. (2007). Immediate and delayed effects of using a classroom case exemplar in teacher education: the role of presentation format. *Journal of educational psychology*, 99(1), 194-206.
- Oser, F. K., & Baeriswyl, F. (2000). Choreographies of teaching: bridging instruction to learning. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 1031-1065). New York, NY: Macmillan.
- Schrader, J., Hohmann, R., & Hartz, S. (Eds.). (2010). *Mediengestützte Fallarbeit. Konzepte, Erfahrungen und Befunde zur Kompetenzentwicklung von Erwachsenenbildnern*. Bielefeld: Bertelsmann.
- Spiro, R. J., Collins, B. P., Thota, J. J., & Feltovich, P. J. (2003). Cognitive flexibility theory: hypermedia for complex learning, adaptive knowledge application, and experience acceleration. *Educational technology*, 42(5), 5-11.
- Zottmann, J. M., Goeze, A., Frank, C., Zentner, U., Fischer, F., & Schrader, J. (in press). Fostering the analytical competency of pre-service teachers in a computer-supported case-based learning environment: a matter of perspective? *Interactive learning environments*.

Acknowledgements

This research has been funded by the Deutsche Forschungsgemeinschaft (DFG).

Vegetation Interaction Game: Digital SUGOROKU to Learn Vegetation Succession for Children

Akiko Deguchi, Faculty of Education Utsunomiya University, 350 Minemachi, Utsunomiya, Tochigi, 321-8505, Japan, deguchia@cc.utsunomiya-u.ac.jp

Fusako Kusunoki, Department of Information Design Faculty of Art and Design Tama Art University, 2-1723 Yarimizu, Hachioji, Tokyo, 192-0394, Japan, kusunoki@tamabi.ac.jp

Shigenori Inagaki, Etsuji Yamaguchi, Yoshiaki Takeda, Graduate School of Human Development and Environment, Kobe University, 3-11 Tsurukabuto, Nada-ku, Kobe, Hyogo, 657-8501, Japan
Email: inagakis@kobe-u.ac.jp, etuji@opal.kobe-u.ac.jp, takedayo@kobe-u.ac.jp

Masanori Sugimoto, Graduate School of Engineering, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan, sugi@itl.t.u-tokyo.ac.jp

Abstract: We developed a Vegetation Interaction Game that supports children's immersive and interactive playing of a simulation game about vegetation succession. To examine the effectiveness of the game, we conducted experimentation in an elementary school. The results of game interaction analysis showed that the game could support children immersively playing and learning regarding vegetation succession.

Introduction

Although previous studies have dealt with simulation games (Barab & Dede, 2007; Squire & Klopfer, 2007), there is no simulation game that dealt with vegetation succession in natural environment. This issue discusses the development of the Vegetation Interaction Game and reports the results of evaluation of this game.

Development of Vegetation Interaction Game

The Vegetation Interaction Game is a digital sugoroku board game that works with Adobe AIR (Adobe Integrated Runtime). Figure 1 is the main window of the digital game; it shows the face of the sugoroku board. Fig. 2 shows six pieces of each plant. The size of the sugoroku board was set at 1024*768 pixels. The surrounding part is the grid area of the sugoroku board, and there are a total of 48 grids. The central part houses the following components of the game: there is an event cards area (figure 1-a), a direction window to move pieces (fig 1-b), and a visualization window to show vegetation succession according to the progress of the game (fig 1-c). We set the event cards to correspond to some kinds of disturbances that could possibly occur in the Mt. Rokko region. There are six kinds of event cards: two large disturbances—tree cutting, landslide; two small disturbances—wild boar, pine weevil disease; no disturbances—fair weather, rain. These are programmed to influence vegetation succession.

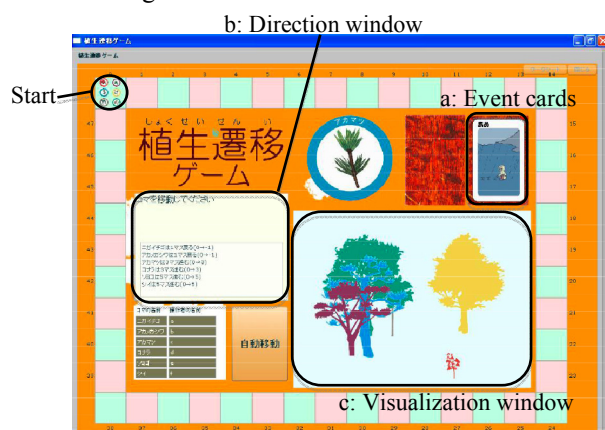


Figure 1. Main Window.

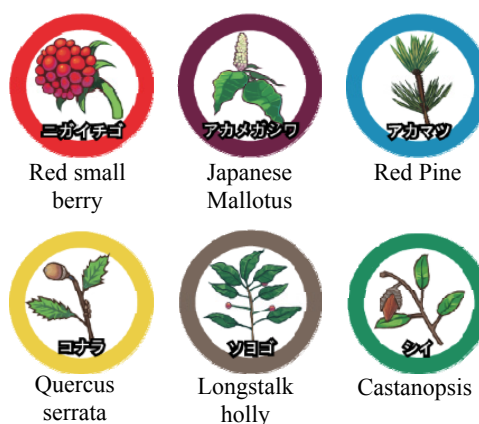


Figure 2. Plant Pieces.

Six players can participate in one game. Each player handles one piece. Players draw event cards, one at a time, by clicking in turn. When a plant piece advances ahead on the board grids, it implies that the plant is dominant in that particular environment. Each piece is to be moved by the number of grids that the current event card indicates. If more than one piece takes the same position on the grid, they will be moved along the grids as indicated by the rules governing the interaction between plants. A game finishes when all event cards are drawn.

Method

Subject: The subjects were 17 sixth grade children (12 years old) in Japanese elementary school. One of the three groups was randomly selected, and interactions of the group were analyzed. The group consisted of six members: three boys and three girls. In addition, five of the six children correctly answered 70% of the total items in game understanding test.

Data and Analysis: To obtain analysis data, the group's statements and actions were video recorded. The recorded data were then transcribed and used for analysis. The transcript was divided into units marking the transitions of the events and plant interaction in game playing. In each unit, we examined children's utterances to clarify whether children were acting as the plants. The children were regarded as "acting as the plants" when their utterances indicated that they empathized with the plants. For example, when the event card "landslide" was drawn, ("Red small berry" holder said) "I did it!!" When interaction between the pieces occurred, ("Red pine" holder said) "Oh no, 'Longstalk holly' came!! I have to return."

Results

The total number of units was 32 and they are arranged in chronological order in Table 1. The gray-filled bar means that "acting as the plants" utterances were made by the child who holds the plant's piece in the unit. In 30 of 32 units, "acting as the plants" utterances occurred. Additionally, there are a total of four units (No. 3, 19, 21, and 32) in which all the children made utterances of "acting as plants". However, the total number of the unit in which 'acting as the plants' were made by fewer than three children, which means fewer than half the member of one group, was 13 units. Looking at this data in greater detail, of these 13 units, 8 units were 'transition of the events,' and 5 units were 'plant interaction.' In addition, total number of units was 22. Of these 22 units, 22 units were 'transition of the events,' and 10 units were 'plant interaction.' So it means that the unit in which 'acting as the plants' were made by fewer than three child accounts 50% in total number of 'plant interaction' units, and 36% in total number of 'transition of the events.'

Table 1: Results of game interaction analysis.

Children	Units															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Red small berry																
Japanese Mallotus																
Red Pine																
Quercus serrata																
Longstalk holly																
Castanopsis																

Children	Units															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Red small berry																
Japanese Mallotus																
Red Pine																
Quercus serrata																
Longstalk holly																
Castanopsis																

Grayed bar fill: 'acting as the plants' utterances were made by the child who held the plant's piece in the unit

Conclusion and Future Task

To make an improvement for this task, following strategy is thought to be effective. In the scene of plant interaction, the power relationship between plants arises, which means when a piece of a child's plant make interaction with other child's plant, it will conquer the other child's plant or will be defeated by the other child's plant. If such kind of power relationships are shown more obviously on the game interface, it could support children got immersive in the phenomena of plant interaction. Future work on this project would involve attacking above improvement, and developing a game that support children's immersive playing and understanding of vegetation succession.

References

- Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for science education: An emerging type of curricula. *The Journal of Science Education and Technology*, 16(1), 1-3.
- Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences*, 16(3), 371-413.

Acknowledgments

This research is supported by Hayao Nakayama Foundation for Science & Technology and Culture for Akiko Deguchi.

Discourse Analysis of Collaborative Meaning Making in CSCL

Shaoming Chai, Jianhua Zhao, Su Mu, South China Normal University, Guangzhou, Guangdong China
Email: charming2000@hotmail.com, jhuazhao@gmail.com, liza_mu@126.com

Abstract: Meaning making is the central to CSCL. This paper proposed to use socio-cultural discourse analysis to study this process. Based on one case study, the paper analyzed the group discourse and identified the five types of discourse. The study showed that this method can be applied to analyze the collaborative learning and meaning making involves different types of discourse acts and they are interweaved into the group discussion and together contribute to the group product.

Introduction

Computer-supported collaborative learning (CSCL) is an emerging branch of the learning sciences concerned with studying how people can learn together with the help of computers (Stahl, Koschmann & Suthers, 2006). Experts at the three international CSCL conferences all emphasized the centrality of the analysis of meaning making to the study of collaboration and proposed that analysis of meaning making should become the focus of collaborative learning research.

CSCL takes a new constructivism and socio-cultural view of learning and views learning is inherently a social, dialogical process in which learners benefit most from being part of knowledge-building communities both in class and outside of school (Jonassen, 1995). In CSCL learners negotiate meaning mainly through language and they engage in group dialogue to establish interpersonal relationship and common ground. It is through discourse that learners construct their knowledge, express their opinions, values and feelings. So examining their talk and text is crucial in order to get at how meaning is constituted locally, we need to focus on the discourse taking place in computer-mediated communication to explore how the group members are engaged in the discourse to negotiate meaning and reach the share understanding by analyzing the discourse.

Research Method and Case

This paper will employ a sociocultural perspective of discourse analysis to analyze the process of collaborative learning. Discourse analysis from socio-cultural perspective is appropriate for our analysis of meaning making in CSCL as it roots in Vygotsky socio-cultural theory (Chai & Li, 2009). It conceives discourse to be interactional actions, laying stress on the social functions of language. From socio-cultural perspective, discourse is situated, action-oriented and constructed (Edwards & Potter, 2001). The analysis should focus on the context, form, meaning and function of the discourse. As discourse performs actions, the researchers need to examine what the participants use language to do, how the meaning is constructed, what the language evidence are and what is related to research question. These questions can help the researcher to analyze the discourse in CSCL to explore the types of discourse, the function of discourse to see how learners negotiate the meaning and solve the problems.

The case was selected from online course discussion in a joint international educational research project "e-China-UK on intercultural professional development. This project involved inter-cultural collaboration between UK and Chinese universities aimed to provide a shared experience in discussing and experiencing e-learning in order to share intercultural perceptions in dialogical and critical collaborative learning settings between the teachers who worked in e-learning fields. The course was delivered via Moodle and lasted 14 weeks. The course consisted induction and three units, and it adopted project-based learning. The group members first got to know each other and tried to build online community and then decide a common topic or problem for group discussion. They needed to explore the topic or solve the problem and worked out a group product. The group discussion data were copied into notepad and saved it as new file for analysis.

Findings and Conclusion

By examine and coding the discourse data in group discussion, I identified the following five types of discourse, and their functions and relevant speech act are showed in the following table.

Table 1: Types of discourse in group discussion.

Type of discourse	Speech act	Function of discourse
Information sharing discourse	Share/ add/give/link resources or ideas	Share the resource and ideas and build a common ground for further discussion.

Exploratory discourse	Ask questions/offer ideas/give comments	Explore the problems by asking questions, offering opinions or evaluations.
Negotiative discourse	Agree/disagree with the ideas	Negotiate the meaning by building on each other's ideas with constructive features
Integrative discourse	Summarize /integrate the main points	Integrate or summarize the main points to make the discussion coherent.
Product-based discourse	Evaluate the product/offer the suggestions/	Discuss how to produce the group work collaboratively

All these five types of discourse occurred in six group discussion and it is through these discourses the participants shared the information, explored the problem, negotiated the meaning and integrated the main points and finally they collaboratively produced a group work by engaging in product-based discourse.

We selected a sample session of group discussion on forum to examine the details of group discourse process to see how they make meaning with the types of discourse as analytical framework. The context for this period of discourse was the group had decided the topic and began to discuss the relevant problems. The analysis showed that when group members participated in group learning, they were engaged in different types of discourse. The group interaction involved asking, clarifying, and proposing discourse acts to explore the question and negotiate the meaning. And their interaction was not one-to-one turn but one to two, or three or all group members. And the discourse was not linear, but took on the multi-directional thread. We can see the group members all actively participated in the discussion and contributed their ideas to the shared problem. And they made the meaning and reached the shared understanding.

How did the group collaborative work out the product? Or how did they make the share knowledge artifacts? When the group members discussed the topic, one learner proposed to use Google docs as an editing tool for their collaborative writing. And the other members took his suggestion and then they began their group work in two spaces, one in group discussion forum in Moodle and one was Google Docs. Here both the discussion forum and Google Docs were mediating tool to support the group's collaborative learning. When they engaged in collaborative writing the group work, each member contributed their ideas to the work. The key words "everyone, our, we, us" and addressors indicated that they were engaged in a group work instead of individual job. And the participants could give some comments to others' texts and could modify or add more ideas to them. And the discourse showed that the group members were collaboratively making meaning and building the shared understanding. The group work was the knowledge artifact that embodies their discourse product. And in fact Google docs could record the collaborator's revision history, including what he or she added, or modified, or commented. From the history revision, we can see the process of the collaborative writing. The product was not the sum of each individual member's contribution, but the result of collaborative work. Discourse analysis of a sample of the group discourse also showed how they collaborative created common ground for group work, built up each other's ideas and produced the shared knowledge artifact.

The study concluded that this method can be applied to analyze the collaborative learning and meaning making involves different types of discourse acts and they are interweaved into the group discussion and together contribute to the group product.

References

- Chai Shaoming & Li Kedong . (2009). Discourse analysis-a new approach to study collaborative meaning making in CSCL. *Modern Educaitional Technology*, 2, 79-82.
- Edwards, D & Potter, J. Discursive psychology. (2001). In A. McHoul & M. Rapley (Eds.) *How to analyze talk in institutional settings . A casebook of methods* (pp.25-38). London: Continuum.
- Jonassen, D. (1995). Learning with technology: using computers as cognitive tools. In D. H. Jonassen (Ed.), *Handbook of research on Educational communication and technology*(PP.693-719). New York: Scholastic Press.
- Stahl, G., Koschmann, T. & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp.409-426). Cambridge, UK: Cambridge University Press.

Acknowledgments

I would like to show my gratitude to all the colleagues in E-china-UK project who contributed to the online course design and implementation especially online discussion. This paper is funded by the key discipline construction of "211" project from Guangdong province, China.

Reflective Practice on Online Collaborative Learning and Knowledge Building in Campus-based Teacher Education Courses

Thérèse Laferrière, Christine Hamel, Laval University, Québec, QC, Canada,
Email: tlaf@fse.ulaval.ca, christine.hamel@fse.ulaval.ca

Stéphane Allaire, Université du Québec à Chicoutimi, Saguenay, QC, Canada, stephane_allaire@uqac.ca

Abstract: The teacher's role in computer-supported collaborative learning is examined from a meso-level perspective using cultural-historical activity theory (CHAT), and in two different contexts. Teachers' goals were online collaborative learning and knowledge building. Over a three-year period these teachers were also researchers and they reflected on their practice in undergraduate and graduate classrooms. Such reflective practice led to more effectiveness as students engaged in new roles and routines in their classroom-based networked communities.

Problem

Online collaborative learning (OCL) and knowledge building (KB) are often thought too complex for students to engage in such activity. We know that electronic forums can bring to OCL or KB relevant support (Scardamalia and Bereiter, 2004; Chickering & Ehrmann, 1996; Stahl, 2006; Weinberger & Fisher, 2006). But the role of the teacher who successfully engages students in OCL and/or KB is still not properly understood.

Theoretical Perspective

Laferrière, Murphy & Campos (2005) argued that reflective analysis was key for CL- or KB-oriented teachers to improve their practice. A reflective practitioner needs data, and micro-analyzes of classroom interaction provide critical information. Meso-level analyzes are also important (Wasson, Ludvigsen, & Hoppe, 2003), thus requiring systemic theoretical perspectives. Engeström (1987, 2001) proposed a framework (CHAT) applicable to the study of activity through computer networks inspired by the cultural, historical tradition. The activity constituents are the following ones: subject(s), object, community, mediating tools (or artefacts), roles, rules and routines. Tensions or contradictions arising within and/or between constituents are to be identified and worked out for innovation to occur.

Methodology

Through reflective practice, two teacher researchers analyzed their roles in large ($N > 100$ students) and small size ($N < 12$ students) classrooms. Content related to the design of learning environments. They taught one of the undergraduate courses together. They taught a new class three years in a row (six courses). Following Schön (1983), they approached effectiveness as the adequacy between pedagogical intents and results. Expected results were defined in terms of students' engagement in the online discourse of their networked community. The choice of the collaborative online space (Knowledge Forum) was negotiated at the onset of each course. Using Knowledge forum analytical tools in their teaching and Engeström's framework in their research they conducted a three-year study.

Results

Context One: Large Undergraduate Classrooms

Most students engaged in onsite/online collaborative learning. They worked in small groups on a problem chosen from a list of problems that the teacher had identified in previous analysis of online classroom discourse. Student participation was scripted. Most students met the expectations as manifested by the scripted roles, and exercised their reflective capacities that demonstrated students' acceptance of "scripted" new roles and "prescribed" routines. The teacher encouraged students to build on one another's ideas. Some small groups engaged in idea improvement.

Context Two: Small Graduate Classrooms

Less structuring was required in small classrooms as more meaning making could take place and participants could develop shared problem spaces. To improve ideas became a lengthy process at times, one full of opportunities for scaffolding and genuine inquiry into the problem space. New norms arose regarding students' online presence, traces of participation and the valuing of participants' contributions to the classroom discourse. In best instances, teacher and students became knowledge builders. The networked communities produced collective artefacts that demonstrated students' acceptance of more open-ended collective inquiry (new routine).

Use of New Tools (Artefacts), Emerging Roles and Related Contradictions

In each undergraduate and graduate classrooms teachers had to engage into negotiation of meaning regarding the relevance of idea improvement (knowledge building) and of collaboration for learning and knowledge building purposes. Teachers' expectations conflicted with most students' previous classroom experience: roles and rules were subject to change. In small graduate classrooms it was easier to achieve onsite/online seamless classroom discourse than in large undergraduate classrooms. Previous online discourse included mediating artefacts that helped provide incoming participants (years two and three) a sense of what could result from their collaboration (e.g., definitions, views that presented issues and challenges, virtual tours of the learning/knowledge building processes). However, to interact online outside the weekly onsite meeting or to leave syntheses of their understanding of a specific design problem in the "semi-public problem space" were not practices students were used to and tensions had to be addressed and lessened. Onsite classroom discussions helped distribute thinking among participants as they worked on the same aspects of a problem at the same time. In the large undergraduate classrooms there was also continuity between onsite and online participation as small group work followed by online interaction occurred also during onsite meetings. Because of the large number of contributions a new database was introduced each year, and a few artefacts from previous years were carried over and some were shown during onsite meetings. Over the years, and through the mediating effect of artefacts and former students' testimonies, students came to class with expectations that contributed to reduce tension. Here are some striking comments made by students after their course/seminar: *- I didn't know this could exist. - It is a resource I helped developed, and one I will go back to. - Not knowing what we were doing at first, we came a long way.* Course evaluations were indicative that students appreciated the opportunity to collaborate. However, only a few undergraduates manifested a clear interest in using collaborative tools with their own students later on. Nonetheless, a number of undergraduate and graduate students continued to refer to the database to which they contributed when they had to design and manage their own learning environments.

Discussion

The two university teachers used new conceptual and technical tools, ones capable of affording authentic collaborative learning/knowledge building through online discourse. As students began to read peers' contributions and to build on one another's ideas, tensions (or contradictions) diminished and a new division of labor/effort emerged (roles), one prompted as well as reflected by classroom norms (community). Graduate students appeared more spontaneously than undergraduate students but it is our contention that, regarding the need to structure (or script) participation, classroom size made more of a difference than course level.

CHAT provided a humblesome perspective on what we could accomplish in a concrete setting as we could not lose sight of the roles, rules, and routines that prevailed or emerged in each classroom-based learning community. While micro-analyses of collaborative learning and knowledge building provided us with fine-grained data, this meso-level analysis led to context-bound observations that also informed our uses of Knowledge Forum. Reflective practice shed light on our role as teachers when it comes to computer-supported collaborative learning and knowledge building. As researchers, we developed a more holistic understanding of the role of the teacher in classroom-based networked communities.

References

- Chickering, A. W., & Ehrmann, S. C. (1996). Implementing the seven principles: Technology as lever, *American Association for Higher Education Bulletin*, 49(2), 3-6.
- Engeström, Y. (1987). Learning by expanding. An activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit.
- Engeström, Y. (2001) Expansive Learning at Work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), 133-156.
- Laferrière, T., Murphy, E., & Campos, M. (2005). *Effective Practices in Online Collaborative Learning In Campus-based Courses*. In P. Kommers, & Richard, G. (Eds.), Proceedings of ED-MEDIA 2005 (pp. 1878-1885). Norfolk, VA: Association for the Advancement of Computing in Education.
- Scardamalia, M., & Bereiter, C. (2004). Knowledge Building. In *Encyclopedia of Education Second Edition*. New York: Macmillan Reference.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
- Stahl, G. (2006). Group cognition: Computer support for building collaborative knowledge. MIT Press.
- Wasson, B. B., Ludvigsen, S., & Hoppe, U. (2003). Designing for change in networked learning environments: Proceedings of the International Conference on CSCL 2003. Boston: Kluwer Academic Publishers.
- Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, 46, 71-95.

Acknowledgments

This study was made possible with a grant from the Social Sciences and Humanities Research Council of Canada.

Exploring Student Understanding of Complex Causality in an Ecosystems-Based Multi-User Virtual Environment

M. Shane Tutwiler, Tina Grotzer, Amy Kamarainen, Shari Metcalf, Chris Dede, Graduate School of Education, Harvard University, Cambridge MA

Email: Michael_Tutwiler@mail.harvard.edu, tina_grotzer@pz.harvard.edu, kamaraam@gmail.com, Shari_Metcalf@harvard.edu, Chris_Dede@harvard.edu

Abstract: Action at a distance, time delays, and non-obvious causes make it difficult to discern the underlying causal patterns in ecosystems (Grotzer, 2009). Multi-user Virtual Environments (MUVES) support science inquiry (Ketelhut, Nelson, Clarke, Dede, 2010) and offer affordances that may help students realize these underlying causal features and their role in ecosystems dynamics. During a pilot study conducted in the spring of 2010, students showed significant improvement in understanding action at a distance.

Research Goals and Theoretical Framework

Ecosystems are inherently complex and dynamic, but research suggests that students have trouble thinking of them as such (e.g. Grotzer & Basca, 2003; Hmelo-Silver, Pfeffer, Malhotra, 2003). Researchers at the Understandings of Consequence Project at Harvard's Project Zero have studied students' specific difficulties in reasoning about causal patterns in ecosystems, such as non-obvious causes, indirect effects, time delays between causes and visible effects, population versus individual effects, and balance and flux (e.g. Grotzer, 2009; Grotzer & Basca, 2003; Grotzer & Honey, 2008).

To address and further study these issues, we developed EcoMUVE, a Multi-User Virtual Environment (MUVE)-based ecosystems curriculum for middle school science. MUVES, such as Harvard's River City Project, have been effective at engaging middle school students in authentic science inquiry (Ketelhut et al, 2010). Building upon ten years of research within River City, the EcoMUVE seeks to extend this design-based research approach, which relies on an iterative cycle of implementation and revision based on student and teacher feedback (Dede, 2005), into ecosystems science education.

EcoMUVE is comprised of two one-week modules that both complement and extend the Understandings of Consequence curriculum. The first module represents a pond ecosystem (Figure 1). Students explore the pond and surrounding area and discover realistic organisms in their natural habitats. Students visit the virtual pond over time – observing; exploring; collecting physical, chemical and biological data; and conducting lab experiments. Students then work in teams to collect and analyze information to solve a mystery about a fish-kill event and to understand the complex relationships within the pond ecosystem.



Figure 1. The EcoMUVE Pond Module.

The second module, currently in development, represents a forest ecosystem. Similar to the pond module, students will collect data, make observations in the virtual world, and conduct experiments. Visiting two islands over the course of multiple decades within the game, students will work together to solve a mystery about predator-prey fluctuations in wolf and deer populations that indirectly affect other species.

Data and Results

Data was collected during the pilot testing of the pond module with 3 teachers and 69 seventh and eighth grade students in the spring of 2010. Students were given a pre- and post-survey of cognitive measures to elucidate their understanding of the complex causal mechanisms of action at a distance, time delay, and non-obvious causes. The preliminary results are presented below (Figure 3).

Students demonstrated significant increases in understanding the importance of action at a distance in analyzing ecosystem problems (McNemar test, $\chi^2(1,69) = 14.73$, $p < .0001$). Scores on questions related to changes over time and non obvious causes also increased, though these results were not significant. Responses to open-ended questions about student causal understanding are currently being coded and analyzed for consistency with the binary data and emerging themes. More data will be collected on the pond module in the fall of 2010, and similar data from pilot testing of the forest module will be collected in the spring of 2011.

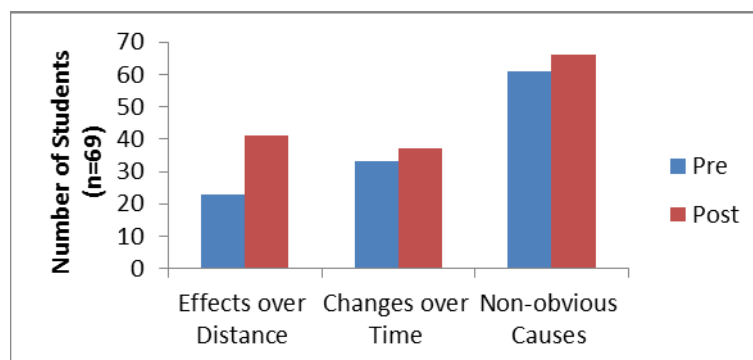


Figure 3. Results of pre-post causal questions.

Significance

Immersive environments support student learning by allowing for multiple perspectives, engaging students in situated learning, and supporting transfer (Dede, 2009). We designed EcoMUVE to test the effectiveness of those affordances – zooming in to the microscopic level and out to a population view, traveling backward and forward in time, viewing emergent effects in a dynamic system, and graphing patterns to see relationships between small behaviors and large outcomes – in order to help students to better understand complex causal patterns in a real-world context.

References

- Adeniyi, E. O. (1985). Misconceptions of selected ecological concepts held by some Nigerian students, *Journal of Biological Education*, 19(4), 311-316.
- Dede, C. (2005). Why design-based research is both important and difficult. *Educational Technology*, 45(1), 5-8.
- Dede, C. (2009). Immersive interfaces for engagement and learning. *Science*, 323(5910), 66-69.
- Grotzer, T.A. (1993). Children's Understanding of Complex Causal Relationships in Natural Systems. Unpublished doctoral dissertation. Harvard University, Cambridge.
- Grotzer, T.A. (2002) *Causal patterns in ecosystems: Lessons to infuse into ecosystems units*. Cambridge, MA: President and Fellows of Harvard College.
- Grotzer, T.A. (2009) Addressing the challenges in understanding ecosystems: Classroom studies. Paper presented at National Association of Research in Science Teaching (NARST) Conference, Orange Grove, CA, April 18, 2009.
- Grotzer, T.A., & Basca, B.B. (2003) Helping students to grasp the underlying causal structures when learning about ecosystems: How does it impact understanding? *Journal of Biological Education*, 38,(1)16-29.
- Grotzer, T. & Honey, R. (2008) Tacit Assumptions that Limit Understanding of Ecosystems, Ecological Society of America Annual Meeting, Milwaukee, WI. August, 4, 2008.
- Hmelo-Silver, C.E., Pfeffer, M.G., & Malhotra, B.A. (2003, April). Fish swim and rocks sit: Understanding structures, behaviors, and functions in a complex system. Paper presented at the American Educational Research Association Annual Meeting, Chicago, IL.
- Ketelhut, D. J., Nelson, B. C., Clarke, J. E., & Dede, C. (2010). A multi-user virtual environment for building and assessing higher order inquiry skills in science. *British Journal of Educational Technology* 41(1), 56-68.

Increasing International Capacity for CSCL: CoReflect, an Example of Sharing and Adapting CSCL Environments across Europe

Iris Tabak, Itay Asher, Samira Nasser, Ben Gurion University of the Negev, Beer Sheva, Israel,
 Email: itabak@bgu.ac.il, asher.itay@gmail.com, nassersamira@yahoo.com
 Eleni A. Kyza, Christothea Herodotou, Iolie Nicolaido, Cyprus University of Technology, Cyprus,
 Email: Eleni.Kyza@cut.ac.cy, chr.herodotou@googlemail.com, Iolie.Nicolaidou@cut.ac.cy
 Andreas Redfors, Lena Hansson, Maria Rosberg, Kristianstad University, Kristianstad, Sweden,
 Email: andreas.redfors@hkr.se, lena.hansson@hkr.se, maria.rosberg@hkr.se
 Cally Oldershaw, Association for Science Education, Hatfield, United Kingdom, callyoldershaw@ase.org.uk
 Constantinos Constantinou, University of Cyprus, Nicosia, Cyprus, c.p.constantinou@ucy.ac.cy
 Hans van der Meij, Twente University, Enschede, The Netherlands, H.vanderMeij@gw.utwente.nl
 Sascha Schanze, Ulf Saballus, Leibniz Universität Hannover, Hannover, Germany,
 Email: schanze@chemiedidaktik.uni-hannover.de, saballus@chemiedidaktik.uni-hannover.de
 Vassilis Kollias, University of Thessaly, Thessaly, Greece, Vkollias@uth.gr

Abstract: We report on differences in collaborative processes that took place when CSCL environments originally developed in one European country were adapted and enacted in another European country as part of the Digital Support for Inquiry, Collaboration, and Reflection on Socio-Scientific Debates (CoReflect) project. We describe what differences were designed and emerged as part of the adaptation process, and discuss implications for principles for cross-national adaptation of CSCL environments.

Adapting Collaborative Learning Environments to Different Contexts

Considerable research in CSCL explores the ways in which collaboration can be facilitated, and the ways in which collaboration contributes to knowledge construction and skill development. Less research examines how collaborative processes change when the same curricular materials or learning environments are used in disparate settings. Yet, this is an important question to consider. The development of CSCL environments is typically resource-intensive, thus the ability to share materials across many settings is important in order to advance the goal of wide-spread dissemination and routine use of CSCL environments. Yet, using the same learning environment in different settings is not unproblematic, and such reuse may require some localization and adaptation in order to succeed (Koper, 2003), including changes related to collaborative processes. Thus, if collaborative processes are key to learning, any changes in these dynamics may also impact learning.

This issue becomes especially challenging when sharing learning environments between different countries as concerns about language and culture contribute to an already complex problem. In this poster, we explore differences in collaborative processes as part of the adaptation of CSCL environments between European countries. On a descriptive level, we present what differences were designed and emerged as part of the adaptation process, and on a prescriptive level we discuss implications for principles for cross-national adaptation of CSCL environments, with special emphasis on how to ensure that collaborative processes are framed in each context in a way that best supports learning.

The CoReflect Project and Cross-national Adaptation

In the work described and discussed in this poster, we collectively report on a coordinated European-based effort to implement web-based computer-supported collaborative learning. The Digital Support for Inquiry, Collaboration, and Reflection on Socio-scientific Debates project (CoReflect, www.coreflect.org) is a project funded by the 7th Framework of the European Commission (“Science in Society”, activity 5.2.2 Young People and Science). It is a collaboration of eight partners from six European countries (Cyprus, Germany, Greece, Netherlands, Sweden, United Kingdom) and an associated state (Israel). Its goal is to explore mechanisms for addressing some of the local problems in science education, focusing on the examination of the transfer of empirically-validated successful CSCL practices to other contexts.

Seven inquiry-based learning environments (LE) were created using the STOCHASMOS (Kyza & Constantinou, 2007) web-based teaching and learning platform. Each LE presents learners with a problem or driving question that asks the students to make an evidence-based decision or recommendation concerning a socio-scientific issue, for example, would you allow the cultivation of genetically modified organisms in your country. The seven environments that were created address the topics of: biotechnology; global climate change; nicotine addiction; sustainable development; fog and humans; astrobiology; and water quality. In each learning environment students work in small groups and access a variety of data sources available in the online learning environment, which also includes a reflective Workspace in which learners can lay out their arguments and connect them to evidence. The learning environment also supports online collaboration through tools that allow

the asynchronous sharing of the groups' WorkSpace pages and a chat tool. Some of the learning environments structured aspects of collaboration and activity around these tools, such as designating pro and con argumentation teams that prepare their arguments through online discussions, and sharing and commenting on their online work using web-based collaboration tools.

Each partner developed a learning environment in collaboration with practicing teachers. Using a design-based research methodology (Design Based Research Collective, 2003), each learning environment was enacted in a pilot study, revised, enacted a second time, and revised. Afterwards, the learning environment was translated to English and passed on to a partner in one of the other participating countries. The adopting partner translated the learning environment into the local language, and created modifications, if needed, in order to accommodate cultural or local school system needs. Hence, each web-based learning environment was enacted in authentic classroom contexts at least three times: twice in the national context for which it was initially designed, and once in a different national context. In all enactments data such as pre- and post-tests, teacher interviews, students' collaborative artifacts from the web-based platform, and audiovisual documentation of students' discourse were collected. In the final, cross-national enactment, analysis also addressed the adaptation process involved in the transfer and implementation of a learning environment into another national context.

In the poster, using our learning environment enactments as case studies (Merriam, 1998), we synthesize and report on successful collaborative practices as well as challenges presented during classroom implementations. We also report on the adaptations, if any, which were undertaken by each adopting partner, focusing on adaptations that relate to CSCL practices. We describe the original design, and explain the rationale for making the reported changes. A broad range of changes were identified during the adaptation of the LEs: from mere translation to an extensive re-conceptualization of the task that included compilation of new content. Criteria for change included the time allotted to specific topics in the curricula of different countries, or the pedagogical style that is typical in different countries.

Cross-national Adaptation of CSCL Environments: Issues & Implications

Based on our analyses, we consider issues that arise from the attempt to build CSCL capacity and possible implications and principles for sharing and adapting CSCL environments between disparate settings:

- *From Prescriptions to Questions* – Adaptive CSCL environments from more directed settings to more autonomous settings can be accomplished by reframing prescriptions as guiding questions.
- *Orchestrating Whole-class and Small-group Collaborations* – Adapting CSCL environments from settings that emphasize skill over content to settings that emphasize content over skills may require a shift to more whole-class collaborations, perhaps reducing small-group collaboration time.
- *Primary and Secondary Adaptations* – Adapting one aspect of a CSCL environment in order to better meet local learning goals (primary adaptation) may require additional changes (secondary adaptation) in order to create better coherence in the resulting, adapted, environment. For example, shifting from a joint deliberation of a moral question to argumentation around a cost-benefit analysis of the same topic (primary adaptation) may also require a shift in the way collaboration is structured (secondary adaptation), but maintaining a design approach while broadening the topic area does not necessarily require additional changes to the mode of collaboration.
- *Best Practices of CSCL* – Despite similarities in rhetoric, different teachers support collaboration in different, ways, and at times, in discrepancy with what is considered collaborative, inquiry-based learning, in the CSCL research community. This can be explained, in part, by the paucity of best practices addressing important classroom issues such as managing, monitoring, guiding and assessing collaborative learning. Thus, in considering how to build CSCL capacity it is important to also direct efforts towards establishing a repository of such practices.

References

- The Design-Based Research Collective. (2003). Design-based research: an emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8.
- Kyza, E. A., & Constantinou, C. P. (2007). *STOCHASMOS: A web-based platform for reflective, inquiry-based teaching and learning: Cyprus: Learning in Science Group.*
- Koper, R. (2003). Combining reusable learning resources and services with pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing Online Resources: A Sustainable Approach to e-Learning* (pp. 46-59): Routledge.
- Merriam, S. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.

Acknowledgments

CoREFLECT (217792) is funded by the European Commission's FP7 'Science in Society' Program. Opinions, findings, and conclusions are those of the authors and do not necessarily reflect the views of the funding agency.

Experiencing, Conducting, Designing and Evaluating Polyphony in CSCL Chats

Stefan Trausan-Matu, University “Politehnica“ of Bucharest, Department of Computer Science and Engineering, Splaiul Independentei, 313, Bucharest, 060042, ROMANIA, stefan.trausan@cs.pub.ro

Abstract: The paper presents an approach that induces a polyphonic structure to a CSCL chat by assigning conflicting concepts (key-words) to each student. The aim of immersing students in a polyphonic (counterpointal, or word-counter-word) experience is to increase inter-animation and, therefore, collaboration. Another major consequence is that such a design facilitates the analysis of the collaboration and personal contributions of students, starting from the degree in which they consider others' words.

Introduction

Starting from the idea that dialogic opposition is present in any human activity (Bakhtin, 1984), learning may be “seen as the process of multiple voices coming into contact, both within and across speaker-produced utterances” (Koschmann, 1999). In Bakhtin's vision, words have a more complex role than in a semiotic or a classical Natural Language Processing perspective. They have a major role because they carry echoes of their usage in previous utterances, they become multi-voiced (Bakhtin, 1984). Moreover, words may be seen also as voices, an important role having the presence of “others' words” in somebody's utterances.

Repetition of words is also very important. It may take different forms and it may have different roles, for example an indicator of the involvement of participants in conversations (Tannen, 2007). Considering the special case of CSCL chats, repetition of words has a major role in polyphonic structuring and in inter-animation patterns (Trausan-Matu, Stahl and Sarmiento, 2007).

Based on the above ideas, this paper presents an approach directed towards enforcing a polyphonic structure to a CSCL chat starting from assigning (key-)words (topics) for each participant and encouraging debates with the aim of increasing inter-animation, collaboration and knowledge construction. The goal is to provide a polyphonic (counterpointal, see Trausan-Matu & all, 2007) experience to the learners. Such a design facilitates the analysis of the collaboration and personal contributions of students, starting from the distribution of their own and the “others' words” (Bakhtin, 1984) in the conversation.

The Polyphonic Model of CSCL and Its Experience

Polyphony, a concept introduced in music, is an example of a joint achievement of several independent participants acting sequentially (singing or emitting utterances), starting from a common *theme* and meanwhile keeping coherence among them. Polyphony may occur in musical pieces with more than one melodic line (or *voice*) at a time, in contrast with monophony, where a single voice (part) is present. Polyphony differs also from homophony because, even if in both cases multiple voices are present, in the former they have a degree of independence. Moreover, even if they are independent, in order to achieve polyphony, voices obey some implicit constraints, some so-called counterpoint rules, for example, in order to achieve a joint harmonic, pleasant musical piece. Polyphony may be seen as a model of group interaction and creativity (as in jazz), in which independent individuals (voices, in a metaphorical sense) achieve a joint activity during a period of time.

The polyphonic model of CSCL group interaction considers, similarly with the musical case, that the students are *experiencing* the presence of a number of concurrent voices (in an extended sense), each of them having independence but contributing to a joint discourse. The *theme* is the discussion subject or the problem to be solved assigned by the teacher or tutor. There is an implicit unity tendency imposed by the need of achieving joint learning goals collaboratively. Each of the participants emits a coherent sequence of utterances and, interacting in a group, inherently has to solve the transversal dissonances appearing between them, participating to *inter-animation* phenomena along the two *sequential/transversal* dimensions, and two tendencies, *unity/difference* (Trausan-Matu & all, 2007). The experience of debating on others' words, the conflicts that appear and their desired resolution are extremely important, in our opinion, because they foster understanding and creativity.

Designing and Detecting Polyphonic Dialogism in Chatting Virtual Groups

A polyphonic scenario in which inter-animation is induced was used for several years at the “Politehnica” University of Bucharest in a course on Human-Computer Interaction (HCI) for the Computer Science and Engineering students in their last year of undergraduate studies. Students were divided in groups of four and each of them was assigned the task of sustaining one of four technologies presented at the course (chat, forum, blog and wiki) in a 1-2 hours chat. In the first part of the chat conversation, each student had to champion the technology he represented by presenting its features and advantages and criticize the others by invoking their

flaws and drawbacks. In the second part of the chat, they had to discuss on how they could integrate all these technologies in a single online collaboration platform. The result was that students identified themselves with the four words denoting the technologies, and they entered beyond expectations in a word-counter-word debate.

The polyphonic analysis tries to identify inter-animation patterns along the sequential-transversal dimensions and corresponding to two types of forces, centrifugal-centripetal (Trausan-Matu & Rebedea, 2010). The longitudinal dimension may be found in the chains of repetitions of words, which may be seen as parallel voices. The transversal dimension may be detected as dissonances or differential positions among the uses of words (seen as voices). Therefore, the analysis of the longitudinal and transversal dimensions of the polyphonic texture may start from the detection of the repetition of words among participants. The visualization of repetitions and an automatic analysis providing several metrics were implemented in the PolyCAFe system using Natural Language Processing and Social Network Analysis techniques (Trausan-Matu & Rebedea, 2010). For example, in Figure 1, the left diagram, having longer and a higher degree of variation of the word threads (that correspond to the assigned topics “chat”, “blog”, “forum” and “wiki”) among participants (for each student there is a horizontal line containing hers utterances ordered in time from left to right) corresponds to a team with a better collaboration than the right one (the classification of teams’ chats as having a good or bad collaboration was done manually by four tutors for each conversation).



Figure 1. The Threads of the Assigned Topics in a Collaborative Team (Left) and a Less-collaborative (Right) Team.

For the analysis of the degrees of inter-animation and involvement of each student, in addition to PolyCAFe facilities, a new method was used, which considers the relations among students and (their or others’) words, with an emphasis on the utterances considering “others’ words” (Bakhtin, 1984). A good participation is, in this sense, that of a person which emitted utterances containing or referring to others’ words. In this aim are considered the number of utterances in which a student speaks about other topics than her own, refers about utterances containing topics that are not her own and speaks about different topics that the one discussed in utterance she explicitly referred. The analysis of the number of occurrences of the above situations and of some of their ratios gave results similar to those given by the human tutors regarding the contribution of the participants to collaboration and inter-animation.

Conclusions and Further Developments

A polyphonic structuring of a CSCL chat (and implicitly, a polyphonic experience for students) can be conducted by a careful design, in which each learner is assigned a topic to support, which is conflicting with those of the other participants. The result is that the learners experience a kind of polyphonic experience, in which each of them “sings” her voice but, meanwhile, they interfere in a counterpointal way to the others’ voices. This design simplifies the evaluation of the collaboration degree and of the participation of the learners. The first validation showed that the results of the polyphonic analysis are close to those of tutors which only read the chat for the evaluation.

References

- Bakhtin, M.M. (1984). *Problems of Dostoevsky’s Poetics*, University of Minnesota Press, Minneapolis
- Koshmann, T. (1999). Toward a Dialogic Theory of Learning: Bakhtin’s Contribution to Understanding Learning in Settings of Collaboration, in C.Hoadley and J. Roschelle (eds.), *Proceedings of the CSCL 1999 Conference*, Stanford, Laurence Erlbaum Associates
- Tannen, D. (2007). *Talking Voices: Repetition, Dialogue, and Imagery in Conversational Discourse*, second edition, Cambridge University Press.
- Trausan-Matu, S., Stahl, G., Sarmiento, J. (2007). Supporting Polyphonic Collaborative Learning, *E-service Journal*, vol. 6, nr. 1, Indiana University Press, pp. 58-74.
- Trausan-Matu, S., & Rebedea, T. (2010). A Polyphonic Model and System for Inter-animation Analysis in Chat Conversations with Multiple Participants. In A. Gelbukh (Ed.), *Computational Linguistics and Intelligent Text Processing*, LNCS, Vol. 6008, Springer Berlin / Heidelberg, pp. 354-363.

Acknowledgments

The research presented in this paper was partially funded by the projects no. 212578, FP7-ICT-2007-1-4.1 LTfLL (<http://www.ltfll-project.org/>) and project no. 264207, FP7-REGPOT-2010-1 ERRIC (<http://erric.eu>).

GroupNotes: Encouraging Proactive Student Engagement in Lectures through Collaborative Note-taking on Smartphones

Mark Reilly, Haifeng Shen, School of Computer Science, Engineering and Mathematics, Flinders University, Australia

Email: m.reilly@flinders.edu.au, haifeng.shen@flinders.edu.au

Abstract: The lecture is still the primary teaching and learning form in university, but student disengagement caused by the traditional didactic style of lecture prevents students from taking full advantage of this learning paradigm. In this paper, we apply a student-centered collaborative learning pedagogy into the lecture environment through a novel Smartphone-based real-time collaborative note-taking application - GroupNotes - that encourages students to proactively engage themselves by means of student-student interaction in a lecture.

Introduction

A lecture is the primary teaching paradigm in most universities. During this time, the lecturer delivers information to students, who process the information passively, and in isolation, to build the relevant knowledge for themselves. The lack of feedback or interaction, at the time when it is most needed for a student to process relevant information during the lecture is a major factor toward student disengagement, which consequently causes negative impacts on their willingness to attend lectures and on their learning outcome. If a student cannot ask the lecturer (Hitchens and Lister 2009) or their peers critical questions at the right time to reconcile their own understanding, they may lose interest and find other ways to occupy themselves (Perry 2000).

In recent years, much attention has been paid to re-designing lectures in a bid to incorporate lecturer-and-student interaction by taking advantage of new teaching gadgets such as clickers, mobile phones, tablets, and laptops (Davis, Landay et al. 1999; Kam, Wang et al. 2005). Empirical evidence as to how student engagement can be improved by these tools as well as to their effectiveness in increasing student learning outcomes is yet to be proven (Patry 2009). In addition, many lecturers have yet to be convinced of making extra effort to re-design their lectures in order to harness these new technologies and students are generally unwilling or unable to own the specific devices, bring them to lectures or invest in learning how to use the devices or applications such as *Livenotes* (Kam, Wang et al. 2005) and *NoteBlogger* (Simon, Davis et al. 2008).

In this paper, we present a technical approach that allows a small group of students to participate in a real-time collaborative note-taking session using their own Smartphones, and motivate, assist, and monitor each other in order to actively learn and keep everyone in the group engaged during the lecture, in a way that does not disrupt the lecture, either for the lecturer, or for other students.

Applying a Student-centered Collaborative Learning Pedagogy into Lectures

We address the issue of student disengagement from a different perspective by introducing a student-centered collaborative learning pedagogy into lectures. Our primary objective is to encourage students to proactively engage themselves in a lecture by facilitating them to actively take notes - a proven effective learning technique that aids memory of the lecture by fostering encoding, articulation and rehearsal (Bligh 2000).

First, a student-centered collaborative learning pedagogy is proven effective in group-based learning tasks or activities in small classes (Kam, Wang et al. 2005); (Falkner and Munro 2009). However, application of this pedagogy to large-class lectures is still under exploration. We want to study its positive effect on improving student engagement and learning outcomes and also investigate any potential negative effects that may develop.

Second, the approach is also based on an active learning pedagogy, where students take a proactive role in engaging themselves rather than being passively kept engaged by the lecturer. Note-taking is an effective learning technique particularly in lectures, where students engage themselves to make sense of the lecture by documenting their understanding or misunderstanding of the information passed on by the lecturer in their initial knowledge building process. However, as note-taking is a personal choice rather than a curriculum requirement, students who do not take notes may not be actively engaged unless other means are used. We want to investigate how to motivate students to proactively take notes in a more engaging and stimulating way.

Third, we want to address the issues responsible for the slow uptake of hardware-based teaching innovations in lectures by investigating Smartphone-based student-student interaction. This approach does not require the lecturer to re-design the lecture and it adds no extra burden to students, either cost to own, time to learn, or effort to bring with them.

In a nutshell, Seven Principles for Good Practice in Undergraduate Education (Chickering and Gamson 1991) advocates, amongst others, developing reciprocity and cooperation among students, using active learning techniques, emphasizing time on task, and giving prompt feedback. While this idea is from the teaching staff to

the students, we aim to provide similar practices from each student to their peers in a collaborative learning group based on the hypothesis that the fun factor (e.g., Smartphone against paper-and-pen, collaborative learning against individual learning) and the peer motivation (e.g., the desire to help peers or not to let peers down) will be driving forces towards students proactively engaging themselves in lectures. We need to systematically develop this technical approach and then test this hypothesis.

A Real-time Collaborative Note-taking Application on Smartphones

The cornerstone of the approach is an application called *GroupNotes*, which operates on Smartphones, and provides for a small group of students to validate and explore the meaning of lecture content in real time through taking their own notes, while also reviewing, commentating, and questioning notes written by other group members as it is delivered, yet in a silent manner that does not disrupt either the lecturer or other students.

The user interface design of the *GroupNotes* application is concerned about issues such as utilization of screen space, simplicity and ease-to-use, efficient use of major functions, unobtrusiveness of minor functions, user control and freedom, and awareness of group work. The user interface design allows for adequate user control and freedom, ranging from individual to cooperative and collaborative uses of the application. Individual use does serve the purpose of engaging students while allowing students to be in control of their own preferred learning styles and to have a digital form of their own notes.

Cooperative use of *GroupNotes* is where a student, though being part of a group, independently take notes for the entire lecture slides because they cannot manage the cognitive load involved in keeping up with their peers' contributions while at the same time listening to the lecturer and taking their own notes, or only for a subset of the lecture slides to take on a fair share of the workload in the group. In this instance each member's notes form part of the community notes available to all group members.

Collaborative use of *GroupNotes* usually involves participants taking different roles, e.g., a note-taker, a reviewer, a commentator, or a questioner, in a real-time collaborative note-taking session in order to maximize each one's strength and cognitive power.

GroupNotes allows a group of students to take advantage of the power of social learning through small-scale "Wisdom of Crowds" (Surowiecki 2005), where cognitive diversity provides multiple views on the current subject matter to challenge or validate the current 'knowledge' of the student at the teaching moment.

Conclusions and Future Work

Low attendance rate and student disengagement in lectures are the common problems in most universities. Our approach encourages a student to proactively keep herself/himself engaged by allowing her/him to voluntarily participate in student-student interaction within a virtual group using her/his everyday pocket device. Preliminary student feedback has shown that the approach is pedagogically and technically feasible and students are quite open to this approach due to its fun factor and peer motivation.

The current *GroupNotes* application is being developed for Android-based Smartphones however to address platform agnosticism, we will also develop versions for other mainstream Smartphones such as the iPhone, Windows Phone etc. We will also study human factors and pedagogical issues in a near future.

References

- Bligh, D. A. (2000). *What's The Use of Lectures?* San Francisco, CA, Jossey-Bass.
- Chickering, A. W. and Z. F. Gamson (1991). "Seven principles for good practice in undergraduate education." *New directions for teaching and learning* 1991(47): 63-69.
- Davis, R. C., J. A. Landay, et al. (1999). NotePals: lightweight note sharing by the group, for the group. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 338 - 345.
- Falkner, K. and D. S. Munro (2009). Easing the Transition: A Collaborative Learning Approach. *Eleventh Australasian Computing Education Conference (ACE 2009)*,65-74.
- Hitchens, M. and R. Lister (2009). A Focus Group Study of Student Attitudes to Lectures. *Eleventh Australasian Computing Education Conference (ACE 2009)*,93-100.
- Kam, M., J. Wang, et al. (2005). Livenotes: a system for cooperative and augmented note-taking in lectures. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 531 - 540.
- Patry, M. (2009). "Clickers in Large Classes: From Student Perceptions Towards an Understanding of Best Practices." *International Journal for the Scholarship of Teaching and Learning* 3(2).
- Perry, B. (2000). "How the Brain Learns Best." *Instructor*; Primary ed 110(4): 34-35.
- Simon, B., K. Davis, et al. (2008). Noteblogging: taking note taking public. *Proceedings of the 39th SIGCSE technical symposium on Computer science education*, 417-421.
- Surowiecki, J. (2005). *The Wisdom of Crowds*. New York, Anchor.

Crafting Identities: E-textile Artifacts as Mediators in High Tech Communities

Deborah A. Fields, Yasmin B. Kafai, University of Pennsylvania, 3700 Walnut Street, Philadelphia, PA 19104
Email: defields@upenn.edu, kafai@upenn.edu

Abstract: Much research has demonstrated the use of digital media as a means of creative expression, yet skilled technical practices still remain inaccessible to many youth. One challenge to broadening participation in this field is making high tech design more accessible. In this poster we suggest that creating e-textile artifacts, objects that sit in tension between engineering and sewing crafts, is one way for youth to craft identities that are meaningful personally and to local social groups and broader technical communities. Drawing from analysis of e-textile artifacts and presentations by two groups of youth from different workshops, we argue that the personal design and genre-crossing nature of such artifacts are key in their ability to mediate between personal legitimacy and broader identification with high tech communities.

Introduction

Much research has focused on the importance of digital media in providing means for social and creative expression in youths' daily lives (Ito et al., 2008). Yet the practices of "geeking out," those practices that involve the most fluency in technical design, have been less accessible, in particular because high tech communities have been described as a 'locked clubhouse' (Margolis & Fisher, 2002). Helping youth identify as part of these communities – through both their sense of self and their ability to participate in practices relevant to high tech communities – is a challenge to broadening participation. Drawing on researchers who have pointed out the power of creating appropriate artifacts that can mediate belonging in a community (e.g., Barton, Tan & Rivet, 2008), in this poster we suggest that e-textiles, which merge the design and programming of electronic circuits with crafts (e.g. sewing), can promote youths' identification with high tech communities while also allowing them to express personal interests and build relevance with local social groups like friends and classes.

Artifacts are symbolic objects that convey meaning and mediate activity (e.g., Cole, 1996). People create and use these symbolic objects to manage their thinking, mediate social interactions, and identify themselves. Barton et al (2008) point to artifact creation as one of the successful mechanisms that allowed urban girls to bring aspects of themselves from other social settings into a science classroom and identify both with popular fads that created relevance with friends and also as interested in and good at science. Here we go a step further to suggest that the e-textiles youth created in two workshops we led allowed them not only to build relevance with their local peers but also express personal interests and connect themselves to the technological community writ large. The e-textiles provided them with the opportunity to express themselves and to learn skills which placed them as part of a community of people who use circuitry.

Methods and Findings

In 2010 we ran two extended e-textile workshops, a four-week after-school club for 8 middle school youth and a two-week long summer day-camp for 12 high school youth. The findings are based on interviews, presentations, and documentation of the youths' designed e-textiles, supplemented with participant observation and video recordings of the processes of creation of these artifacts. Based on grounded theory (Charmaz, 2000), we performed a two-step, open-coding of youths' descriptions and demonstrations of their projects in social context, including which comments brought responses from audience members (peers and teachers). The analysis revealed themes of artifacts as a nexus of personal creativity and interests, artifacts as a means for local relevance with peers, and artifacts as a mediator for academic relevance and membership in broader imagined tech communities. Though space is limited here, we describe how some projects relate to the larger findings.

Below are four examples of projects youth made (see Figure 1): a shoe with an RGB light, a bag for "Mom" with a cat whose left eye lit up, a backpack with turn signal arrows connected to a switch on a shoulder strap, and a "pocket ninja" that lit up when pressed (see Figure 1). The most obvious theme, personal creativity & interests, is evident in that these youth were all offered the same materials—LEDs, coin cell batteries, switches, and conductive thread—but creatively designed their projects for different purposes (e.g. functional turn signals, gift) and to show different interests or personal qualities (interest in anime, uniqueness in using keychain to conduct electricity to other colors on the shoe). The next theme, local relevance with peers, is demonstrated in the youths' presentations through their uses of humor and references to shared trials. For instance, the creator of the pocket ninja elicited chuckles from her peers when she described how much work her project took, "So I was up until like 2 o'clock in the morning to finish the ninja? And 3 o'clock trying to get this light on." Other presenters drew similar chuckles, sighs, nods, and groans when they presented their creations,

building shared relevance with their peers in the workshops. The final theme of relevance and membership in broader tech communities appeared in some of the larger discourses exhibited in the talk surrounding the projects. Many of the students, without being asked, demonstrated how their circuits worked, gesturing to the orientation of positive and negative ports or parallel circuits. Others commented on the high goals they had set for their projects even though they had not attained them (yet).



Figure 1: Pictures of E-textiles Artifacts: Shoe, Mommy Cat Bag, Turn Signal Jacket, Pocket Ninja.

Discussion

We found that the explanations and projections tapped into a larger discourse relevant to either the local academic setting (e.g., school) or an imagined community of tech people who were ‘better’ and more proficient at the activities. In the context of the middle school group the conversations were about explaining the functioning of the circuits whereas in the context of the high school group, which took place at a School of Science and Engineering at a prominent university, they referenced the engineering community. One explanation for this difference in imagined audiences is the presence of undergraduates and professors of Computer Science at the high school camp, where the emphasis was on training them to be future participants in Computer Science in college. Regardless, both groups of students, without direct coaching, worked to be relevant to an academic audience and related technology community. We argue that one reason is because of the genre of the artifacts. E-textiles tap into fields of engineering/computer science as well as arts/crafts. Both the engineering and artistic components are highly gendered and this puts the students in a unique place that provides multi-dimensional space in which the design of these artifacts plays out. We found that the self-designed artifacts in this context can have multiple purposes and can be utilized in ways that reveal inventiveness with connectors and materials as well as personalization. In addition, they have the potential to be boundary-crossing objects that cross social settings of home, peers, school, and larger communities (technological/professional, affinity groups). As such the e-textiles reflect youths’ efforts in ‘crafting’ their identities not only in the most literal sense but also by signifying relevance to themselves, to local community, and to imagined broader communities (see also Enyedy, Danish & Fields, in press). Future work will examine how the contributions of e-textile artifacts to an online community called the Lilypond, containing hundreds of different e-textile artifacts, helps situate young designers’ sense of belonging to a burgeoning e-textile community.

References

- Barton, A., Tan, E., & Rivet, A. (2008). Creating hybrid spaces for engaging school science: How urban girls position themselves with authority by merging their social worlds with the world of school science. *AERJ*, 45, 68-103.
- Charmaz, K. (2000). Grounded theory: Objectivist and constructivist methods. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 509-535). Thousand Oaks, CA: Sage Publications.
- Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge, MA: Harvard University Press.
- Enyedy, N., Danish, J. & Fields, D. A. (in press). Negotiating the “relevant” in culturally relevant mathematics. *Canadian Journal of Mathematics*.
- Ito, M., Baumer, S., Bittanti, M., boyd, d., Cody, R., Herr, B., Horst, H. A., Lange, P. G., Mahendran, D., Martinez, K., Pascoe, C. J., Perkel, D., Robinson, L., Sims, C., & Tripp, L. (2009). *Hanging out, messing around, geeking out: Living and learning with new media*. Cambridge, MA: MIT Press.
- Margolis, J. & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing*. Cambridge, MA: MIT Press.

Collaborative Knowledge Building for Understanding Science Concepts

Pei-Chen Tsai, Huang-Yao Hong, Chieh-Hsin Chiu, National Chengchi University, Taiwan,
Email: 98152014@nccu.edu.tw, hyhong@nccu.edu.tw, 99152003@nccu.edu.tw
Ming Hong, Taipei Municipal Mu-Ja Elementary School, Taipei, Taiwan, minghong@tp.edu.tw

Abstract. This study explores the effects of knowledge building on students' understanding of some science concepts. Data mainly include: (1) students' online discourse; and (2) a test with open-ended questions for assessing students' understanding of concepts pertaining to some environmental issues. Preliminary findings suggest that with support from knowledge building pedagogy and technology, students were able to work collaboratively and opportunistically with emerging ideas and to gain deeper understanding of the science concepts under study.

The students in the current study are engaged in knowledge building, in their interactions with each other, as part of an online community supported by Knowledge Forum—a computer-supported knowledge building environment—and in their work with producing and refining ideas for solving some environmental problems. Knowledge building is a social process focused on sustained production and improvement of ideas of value to a community (Scardamalia & Bereiter, 2006); and it supports an idea-centered collaboration—a non-group-based, unplanned, and opportunistic way of working with knowledge in a community (Hong, in press; Hong & Sullivan, 2009; Zhang, et al., 2009). This is different from conventional group-based teamwork in which students are often assigned defined roles for completing a holistic task by doing parts of it (Aronson & Patnoe, 1997; Slavin, 1983). Such group-based, task-driven concept of teamwork has been widely used for conventional school learning (Slavin, 1983). In the study reported below, we are interested in finding out whether introducing the alternative, idea-centered collaboration would affect students' science learning.

Method

Participants were two classes of fifth-graders from Taiwan. The control class (n=33) employed conventional instruction that highlights group learning, with each group being required to master a different sub-topic of the main topic (i.e., energy saving and carbon reduction), and then share what they learned with other groups (Aronson & Patnoe, 1997). In contrast, the experimental class (n=34) adopted knowledge building pedagogy and Knowledge Forum (KF) technology to engage students in idea-centered collaboration by working opportunistically with emerging ideas without being limited within groups. Data mainly came from notes recorded in KF and a final test on students' understanding of the main science topic studied. For the first dataset, we calculated student online activities from the first to the second stage, using midterm as a separation point, over the 18-week semester. In particular, we coded students' activities into four types of behaviors: social talk with no obvious ideas generated, idea-generating, idea-sharing, and idea-improving (Hong & Sullivan, 2009). In terms of the second dataset, the final test asked students to (1) define what energy saving and carbon reduction is, (2) explain why it is important, and (3) describe all possible ways to put it into practice. A scoring scheme was developed; students were given one point each time when a concept (for Q1) or reason (for Q2) or means (for Q3) related to energy-saving or carbon reduction was present in a student's answers. Below are three examples of student answers: "It means to waste as less energy as possible and to reduce the emission of carbon dioxide to the environment" (for Q1); "It is because conserving energy and lessening carbon remission can slow down the greenhouse effect" (for Q2); and "To grow some plants at home" (for Q3).

Results

As Table 1 shows, there was an increasing trend (from the first to the second stage) of students' general online activities, whether they are note-creating, -reading, or -linking behaviors. Specifically for the note-linking behaviors, there is a statistically significant increase, suggesting that students spent more time working together. To further look into idea-related online activities, we identified all ideas in the database and analyzed how they were generated, shared, and refined. On average, every student generated 16.1 ideas (SD=9.77) about conserving energy or reducing carbon remission. These ideas were mostly concerned with life-styles, for example, eating (n=150), housing (n=158), and commuting (n=118). Table 2 further shows number of ideas that were shared, exchanged, and refined from the first to the second stage of the semester. Clearly, there was a trend of decreasing numbers of social talks and idea sharing (in terms of idea quantity), and that of increasing numbers of idea exchange and improvement activities (in terms of idea quality). Moreover, in terms of learning outcomes, we analyzed the final test on students' understanding of concepts related to energy saving and carbon reduction. The results showed an overall significant difference between the experimental and control groups (all questions combined, $M=3.06$, $SD=1.36$, for the experimental group; $M=2.67$, $SD=1.06$, for the control group; t

=2.10, $p = .04 < .05$). In particular (Table 3) the experimental group outperformed the control group in terms of students' understanding of what energy-saving and carbon reduction is, and why it is important.

Table 1: General online activities in Knowledge Forum.

General online activities	1 st stage		2 nd stage		t-test
	M	SD	M	SD	
# notes created	7.65	6.34	8.12	3.62	-0.459
# notes read	34.71	28.91	42.03	30.97	-3.455
% of notes linked	41.71%	32.30%	61.74%	29.57%	-1.128**
1. # of group notes created	2.47	1.30	3.04	2.12	0.089
2. # of build-on notes	4.78	4.28	4.15	2.64	0.441

** $p < .01$

Table 2: Occurrence of specific idea production and improvement related activities in Knowledge Forum.

Activity	Example	Stage		t-test
		1 st	2 nd	
Social talk	You have fewer ideas than mine. Go, go, go!!! (A22)	31	2	2.634*
Idea generation	My idea is to take more public transportation. (A03)	116	96	.952
Idea sharing	Are there other kinds of gas that cause greenhouse effect? (A16)	76	93	-.821
Idea improvement	I think your idea is good, but a better idea is to drive less. (A05)	27	94	-4.304***

** $p < .01$ *** $p < .001$

Table 3: Assessment of students' understanding of science concepts tested in this study.

	Experimental		Control		t-test
	M	SD	M	SD	
Concept	2.90	1.22	2.03	1.02	2.60**
Reason	2.52	1.45	1.84	0.85	2.17*
Means	3.77	1.40	4.00	1.31	-.29

* $p < .05$ ** $p < .01$

Discussion

Scientific knowledge is socially constructed (Latour & Woolgar, 1986; Merton, 1973). Yet research shows that students have little understanding of science being a social enterprise that values collaborative creation (Driver et al., 1996; Hong, in press). Instead of engaging students in conventional group-based teamwork and learning, the present study engaged students in idea-centered knowledge building. The results show that students were more likely to engage in an opportunistic way of collaboration when dealing with emerging ideas. Moreover, they were more likely to gain deeper understanding of some key science concepts under study. An important aim of the present study is to probe into the meaning of the design difference between the two types of collaboration (idea-centered vs. group-based). As such, this study was largely conducted in a naturalistic context rather than in a highly controlled experiment situation. Therefore, it remains to be further examined whether idea-centered collaboration can be truly accountable for the effectiveness observed in the present study. To this end, further interaction and discourse analyses will be conducted to fully answer the research questions.

References

- Aronson, E., & Patnoe, S. (1997). *The jigsaw classroom*. New York: Longman.
- Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's image of science*. UK: Open Univ. Press.
- Hong, H.-Y. (in press). Beyond group collaboration: Facilitating an idea-centered view of collaboration through knowledge building in a science class of fifth-graders. *Asia-Pacific Education Researcher*.
- Hong, H.-Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research & Development*, 57(5), 613-627.
- Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.
- Latour, B., & Woolgar, S. (1986). *Laboratory life*. Princeton, NJ: Princeton University Press.
- Merton, R. K. (1973). *The sociology of science*. Chicago: University of Chicago Press.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*. Cambridge: Cambridge Univ. Press.
- Slavin, R.E. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin*, 94, 429-445.
- Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *Journal of the Learning Sciences*, 18(1), 7-44.

Design and Development of a Formative Assessment Tool for Knowledge Building and Collaborative Learning

Jan van Aalst, Carol K. K. Chan, Yuen-Yan Chan, Wing-San Wan, Stella Tian, The University of Hong Kong, Pokfulam Road, Hong Kong

Email: vanaalst@hku.hk, ckkchan@hku.hk, yychan8@hku.hk, wan.zero@gmail.com, stellat@mail.ustc.edu.cn

Abstract: This work proposes a theoretical perspective on formative assessment that is more consistent with knowledge building. Based on this, a system for assessing knowledge building and collaborative learning was designed and developed. The system converts a Knowledge Forum tuplestore to an SQL database and then utilizes queries based on four types of general questions students may have about their work. We also report results from usability trials.

Introduction

There is much interest in education in the analysis of discourse — writing, reading, and other actions — in Web-based environments. The best known environments include learning management systems like Moodle® and WebCT®, and more specialized inquiry environments such as Knowledge Forum®. However, there still is a lack of tools that are widely available for analyzing this discourse. The premise of the work reported here is that it is important that students have access to information about their collaborative discourse, with a view to improving their performance. That is, we look to server logs as a potential source of information that can be used for formative assessment (Black & Wiliam, 1998). This is particularly important for knowledge building, which emphasizes epistemic agency and self-assessment.

Goals

This work aims at using current software technologies to enhance knowledge building and collaborative learning through formative assessment. We designed and developed a web-based tool which works with general CSCL platforms such as Knowledge Forum®. The objectives of the project were:

1. To develop a theoretical perspective on formative assessment that is more consistent with knowledge building and collaborative learning,
2. To develop indicators that are intuitively linked to the most important aspects of 1; and
3. To design and implement a web-based formative assessment tool based on the indicators in 1.

Theoretical Framework

Knowledge Building

Knowledge building is an educational model that involves computer-supported discourse, in which students' efforts are directed at advancing the collective knowledge in a community (Scardamalia, 2002). Students are not just trying to understand things for themselves but aim to add something new to what is known in the community. Knowledge building can be supported by CSCL technologies such as Knowledge Forum®.

Formative Assessment

Since the seminal work by Scriven (1967), there had been various perspectives about formative assessment (such as Black and Wiliam, 1998; Taras, 2005, 2009; Yorke, 2003). We point out that for knowledge building a view of formative assessment is needed that deeply integrates assessment with knowledge building. We consider assessment as the collection of information involved in students' own inquiry into their knowledge building. It is not epistemologically distinct from knowledge building, except that the domain of the inquiry is not subject matter (e.g., science concepts) but the process of knowledge building.

Tool Design and Development

The tool aims at answering the following four questions raised by teachers and students in the context of knowledge building: (1) Are we collaborating? (2) Are we putting our knowledge together? (3) What happens to ideas over time? And (4) What's happening to my stuff?

These questions are motivated by knowledge-building theory. For example, "Are we collaborating?" is relevant to Scardamalia's (2002) principle of individual cognitive responsibility for collective knowledge advancement, and "What is happening to ideas over time?" to the principle improvable ideas. We constructed indicators to answer the above queries, as described briefly below. Wherever appropriate, we also discuss how they can be traced from CSCL usage available in more general systems.

Are we collaborating? We consider the structural features of a community and suggest the concept of “collaborative friends” – participants who interact with one another’s contributions. One can set thresholds for being a collaborative friend (e.g. who build on more than 2 of his/her notes) and ask how many collaborative friends he/she has, and what percentage of participants have at least 4 such collaborative friends.

Are we putting knowledge together? This query reveals the extent to which synthesis and rise-above are occurring. It can be measured by, for example, number of notes that are opened more than once by a same reader (to indicate whether participants are returning to notes at all) and number of notes that include references (links) to other notes (to make connections between notes).

What Happens to Ideas over Time? Two indicators for idea improvement can be *awareness of new concepts* and *use of new concepts*. The former measures how many students have come across to a note with a new keyword introduced (assuming keyword signifies a new concept); the later examine the uses of keywords in new notes and whether the use of a keyword is sustained over time and diffuses through the community.

What’s Happening to My Stuff? This query is presented at individual level. It enables one to learn about gather how they, personally, are doing in the community. For example, one can check about their most influential notes (e.g. which notes created by me were built-on by more than n students?) and monitor the uptake of the notes in the community.

Based on the above perspectives, we designed and developed an assessment system that integrates with Knowledge Forum®. It is developed using contemporary software approach and a flexible, three-tier architecture, so as to cater for interoperability and the integration with other generic CSCL systems. A graphic-rich, user-friendly web interface is provided for teachers and students to self-assess their knowledge building efforts (Figure 1).

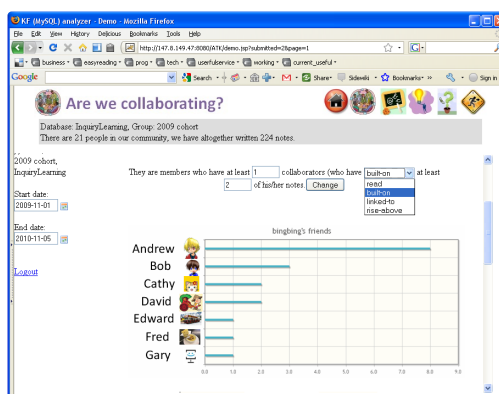


Figure 1. Web-based user interface for answering the questions in natural language, e.g. are we collaborating?

Evaluation for Usability

Preliminary tests for usability have been conducted by inviting teachers who use conducted knowledge building in their classroom to analyze their students’ participation using the proposed system. User feedbacks indicate a positive view with most teachers found the tool useful and enabled them to reflect about possible improvements, for example, identifying at-risk students for further scaffolding and follow up.

References

- Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy, and Practice*, 5, 7-74.
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago, IL: Open Court.
- Scriven, M. (1967). The methodology of evaluation. In R. Tyler, R. Gagne & M. Scriven (Eds.), *Perspectives on curriculum evaluation*. Chicago, IL.: Rand McNally and Co.
- Taras, M. (2005). Assessment - Summative and formative - Some theoretical reflections. *British Journal of Educational Studies*, 53(4), 466-478.
- Taras, M. (2009). Summative Assessment: The Missing Link for Formative Assessment. *Journal of Further and Higher Education*, 33(1), 57-69.
- Yorke, M. (2003). Formative assessment in higher education: Moves towards theory and the enhancement of pedagogic practice. *Higher Education*, 45(4), 477-501.

Acknowledgments

This work is supported by The University of Hong Kong under the Seed Funding Programme for Basic Research (Project #200911159185).

Live Linking of Fieldwork to the Laboratory Increases Students Inquiry Based Reflections

Anne Adams, Tim Coughlan, Yvonne Rogers, Trevor Collins, Sarah Davies, Canan Blake, John Lea, Open University, Walton Hall, Milton Keynes, MK7 6AA.

Email: a.adams@open.ac.uk, t.coughlan@open.ac.uk, y.rogers@open.ac.uk, t.d.collins@open.ac.uk, s.j.m.davies@open.ac.uk, c.tosunoglu@open.ac.uk, j.lea@open.ac.uk

Abstract: The Out There In Here (OTIH) system examines geology students distributed co-reflection and inquiry based learning collaborations using ‘live’ field based mobile technology (e.g. smartphones, ipads, laptops) and laboratory static technologies (e.g. tabletop, large screen displays, PCs). OTIH evaluations involved 23 students with video and log analysis, questionnaires, focus groups and scenario sorting exercises to identify how situated technologies support hypothesis generation with 3 types of collaborative reflection; remote sharing, dialogic and comparative information reflection.

Background

The ‘Out There In Here’ project reviews the specific concepts of situation (laboratory and field based) and togetherness (co-located and distributed groups connected with live interactions) as an impact on reflection within inquiry based learning. Distributed groups were supported in collaborative geology hypothesis generation and reflection through observations and analysis using situational appropriate technologies (i.e. Mobile devices for the field and static collaborative systems in the lab).

The concept of reflection goes back to Dewey's (1933) investigation of reflection along with experience and interaction leading into the work on reflective practice (Boud, 1985). However, these approaches have tended to focus on practice based contexts with reflection as a personal activity. More recently co-reflection has emerged as concept which is defined by Yukawa (2006) as a ‘collaborative critical thinking process’ which involves tacit and active approaches to inquiry learning. The internet's ability to support sharing within a community irrespective of time and space has been noted as valuable in supporting reflection (O'Malley and Scanlon; 1990). However, these approaches have focused on how to increase constructive criticism rather than detailing how these interact with technically mediated time and space. Land (2004) highlights the value for learning of encouraging students to reflect, over time, upon personal concepts through collaborative comparison with different approaches and models. Situational space, in contrast, is an important part of field work in many domains, particularly in the natural and social sciences, by providing a uniquely valuable experience beyond the classroom (Spicer and Stratford, 2001). Research highlights that field work improves learning and retention of information and skills (Kent et al, 1997) as well as improving community engagement and professional identity growth. However, the role of co-reflection in developing these learning outcomes is poorly understood.

Research Trials

In situ evaluations of the system in two full day trials of the system with a total of 21 participants are presented here. Both trials followed the same layout and sequence (See figure 1). In each case a group of 4 students along with a tutor were stationed in the ‘In Here’ room, while another set of students (6 in the first trial and 5 in the second) were taken to a field site (Coombs Quarry in Buckinghamshire) accompanied by another tutor.



Figure 1. OTIH Lab and Field Based Students Use Multiple Devices for Sharing Photos, Maps and Logs.

Mixed methods were used for evaluation with researchers present In Here and Out There to observe interactions. A background questionnaire identified participant descriptive statistics and current technology usage patterns as a baseline to compare with trial interaction patterns and perceptions. Computer logs recorded data shared by co-located and distributed students. The ‘In Here’ room was filmed through several cameras whilst ‘Out There’ a mobile researcher filmed critical incident sequences. Both were thematically analysed for key interaction patterns and learning incidents. The two student groups took part in separate focus groups discussing their trial experiences focusing on: geology learning and technology mediated interactions. This data

was evaluated thematically and key issues were triangulated with findings from other data sources. Both tutors also attended a feedback session after each trial which were included in the analysis.

Results

Descriptive statistics identified that the students all used a computer, however, 60% never used email and 25% used it frequently. The student participants had basic ICT literacy limited to specific technologies and systems (i.e. word processing for coursework). Further analysis identified specific issues around co-reflective learning.

Distributed Co-Reflection

'Live' interactions (a-synchronous on the same day within minutes or hours) gave students a notion of increased importance attached to the sharing activity increasing team bonding and focusing on reflective activities. Three different types of reflective action supported scientific discovery learning:

Remote Sharing Reflection: The reflection occurred through students action of sharing their findings with other remote students inducing reflections. For example: 'this will be interesting because i don't know which one we want to send back or how many we want to send back in one go' (IOT4) 'we need to think of a neat way to summarize this for the in here team' (IOT3) 'I sent that one because its got the shells' (IOT5).

Dialogic Reflection: Further discussion about inquiries produced a dialogue which were full of unspoken assumptions that each student had because of their shared situation both in time and space. The dialogue and contradictions between the two groups were useful to initiate reflections:

In Here: "are there any differences between the fossils in the different beds?" (IHH)

[Pause as Out There team frown, look at the beds and reflect and discuss before agreeing]

Out There "No, no difference." (IOT)

Collaborative Information Reflection: Finally the students at different locations produced information at different levels of abstraction (i.e. the specific to the generic). "(previous field trips participant was on)... looking at grain size, sorting things like that, whereas this time I felt you looked at the whole picture." (IOT6). Contradictions in data at different levels of abstraction often led to deeper reflective discussions and conclusions. For example, the second trial revealed an error found in the published geological maps of the area, this emerged through discussions between those viewing the maps and those viewing the actual rock faces.

Conclusion

The findings highlight the different inquiry roles that students learnt towards within each the field and laboratory situation. Students Out There understandably tended to concentrate on data collection and avoided abstract discussions whilst the In Here students tended towards abstract synthesis and discussions and avoided data collection. However, the research identified how valuable to the student's comprehension it was that the system and procedures encouraged these activities to occur. In particular, students noted the success of avoiding rigid role and sequence assignments whilst scaffolding the learning experience through a focus on distributed sharing and hypothesis generation. Of particular interest was the value attributed to the simple action of distributed sharing which encouraged a wealth of additional reflective activities for those in the field which were previously not supported in traditional approaches to geology field based inquiry learning. In short, sharing with those in remote situations forced students to reflect on information relevance and how to present it out of context.

References

- Boud, D., Keogh., R. Walker, D. (1985) Reflection turning experience into learning. London, Kogan Page.
- Dewey, J. (1933) *How We Think* Revised Edn. D.C Heath Boston
- Kent, M., Gilbertson, D.D. & Hunt, C.O. (1997) Fieldwork in geography teaching: a critical review of the literature and approaches, *Journal of Geography in Higher Education*, 21 (3), 313-332.
- Land, S (2004) 'The Design and Evaluation of a CSCL Tool to Support Reflection and Revision of Design Projects' *Journal of Computing in Higher Education* Volume 16, Number 1, 68-92.
- O'Malley, C., & Scanlon, E. (1990). Computer-supported collaborative learning: Problem solving and distance education. *Computer in Education*, 15(1-3), 127-136.
- Spicer, J. J. & Stratford, J. (2001) Student perceptions of a virtual field trip to replace a real field trip. *J. of Computer Assisted Learning* 17, pp. 345-354
- Yukawa, J (2006) "co-reflection in online learning: collaborative critical thinking as a narrative" *International Journal of Computer Supported Collaborative Learning* pp203, 228. Springer, New York

Acknowledgments

With thanks for, EPSRC funding and Microsoft Research support as well as students and tutor engagement.

Learning Technology by Collaborative Design and Evaluation

Chun Hu, Wai Yat Wong, Vilma Fyfe, University of Sydney,
Email: chun.hu@sydney.edu.au, wai.yat.wong@sydney.edu.au, vilma.galstaun@sydney.edu.au

Abstract: Forth Year Secondary Education students spent five weeks working in pairs to design and develop a web-based learning/teaching resource as their course assignment. Prior to the final submission, the students had their web-based learning resources reviewed by two pairs of peers by using Camtasia. The recorded screen movements were then uploaded as videos to EVA where the students viewed the videos and discussed the peer critiques. The innovative approach was well received by the students.

Conceptual Framework

How to prepare pre-service teachers for technology use in the classroom is an enduring issue. It is commonly agreed that pre-service teachers would benefit the most from exposures to technology integration modeled by curriculum subject faculty members. Yet, in reality, practical reasons often make it difficult for teacher education institutions to take this approach. As a result, stand-alone technology course continues to exist as an important venue for pre-service teachers to be prepared for technology integration in the classrooms. A frequently asked question is how stand-alone technology courses can best prepare pre-service teachers.

Mishra and Koehler (2006) advocate an approach of learn-technology-by-design for preparing technology integration, in which pre-service teachers “propose software and hardware solutions to their specific contexts and problems” (p. 1034). Instead of “direct instruction about particular software programs or technology”, pre-service teachers have “spontaneous and short tutorial sessions - both student to student and instructor to student-driven by the immediate requirements of the groups” (p. 1034). Design-based learning activities are usually carried out in groups and pre-service teachers develop deeper understanding through the experiences of “dialogue and action” and “reflection in action” (p. 1035).

Learn-technology-by-design tasks are accomplished in the environments where pre-service teachers feel comfortable working collaboratively and are encouraged to use ICT tools to build a learning environment where learners could benefit from peer interactions and working collaboratively. Joint construction of knowledge and sharing cognitive load facilitate higher levels of learning (Ploetzner, Dillenbourg, Preier & Traum, 1999), and the possibility of exchanging multiple perspectives forces learners to engage with ideas in a deeper sense (Anderson, 2003).

Research Context and Method

All the 4th year Secondary Education students at the University of Sydney take a compulsory 10-week course (20 hours) – Information Technology in Education. The overall objectives of the course are to create awareness among pre-service teachers of issues related to ICT integration, such as policies, affordances of various ICT tools, and strategies of integrating ICT tools into teaching and learning process. Students are expected to learn at least two technical skills in the course: (1) interactive whiteboard and (2) web page creation. Focuses on these two specific technical skills are in line with the recent development in the national and local educational systems. As part of a recent national initiative, schools are provided with interactive whiteboards and all students from Grade 9 are provided with a laptop computer.

Of the 10 weeks, eight are devoted to the development of the technical skills specified above via two design tasks. Both design tasks follow learn-technology-by-design approach. The tasks are problem-centered and are driven by the solutions to teaching/learning needs. Learners work collaboratively and engage in reflective practice in the design process. For example, for the web page creation (five weeks), students are presented with a problem scenario where they are presumably in-service teachers asked by their superiors to design a short web-based student-centered learning activity that integrates environmental education. To accomplish the task, students would have to demonstrate that they are able to create a simple website consisting of three linked pages. Further, they need to demonstrate that they are able to embed two activities in the website by employing different software applications to enhance intended students’ learning. For instance, a website aimed at bringing awareness of the air pollution caused by car emission could embed (1) an Excel sheet where learners could calculate car emission, and (2) an online forum where they could discuss the impact of air pollution on the environment. Both design tasks require students to work in pairs.

Prior to the final submission of the web creation task, students have their web pages reviewed by two pairs of other students. To complete the peer review, students go through their peers’ web pages and fill out a paper-based peer review form abstracted from the assignment marking criteria. Students are also offered with the opportunity of using screencast software Camtasia and educational video with collaborative annotations (EVA) in their peer review process. Camtasia allows recordings of screen activities (mouse movements and

clicks) and students' conversations while going through the pages being reviewed. EVA is a web-based teaching and learning platform that consists of video streaming, indexed video cue-segments, and associated list of users' annotations (Wong & Reimann, 2009). Consequently, students view the video recordings and discuss the peer feedback via EVA. This report is based on the data collected from 18 (9 pairs) students from an intact class in 2009, focusing on the students' perceived benefits of collaborative design and evaluation. The data was gathered from the students' project development reports and reflections. The report does not include the analysis of the peer evaluation or the impact of peer review as a formative evaluation on the students' final work, which have been reported elsewhere previously (Hu, Wong, Fyfe & Chan, 2010a, 2010b).

Findings and Discussions

All the students responded positively to the approach of learn-technology-by-design. The students considered working collaboratively to design/develop web-based learning activity a meaningful experience. One pair of students described how they originally planned a learning task that asked students to create a poster by using Word or PowerPoint. After some discussions, they decided that the task "would not attain much success in terms of interactive learning, as well as a strong encapsulation of ICT". Instead, they decided to embed an Excel sheet in their webpage with which "students are able to interact with the use of technology, whilst at the same time gaining a visual aid on the unit that is being taught to them".

The students were overwhelmingly positive about the formative evaluation through peer feedback. One student wrote: "I particularly enjoyed the opportunity to give others critiques of their creation and also receive critiques from our peers of our own creation. This process allows us to constructively learn from other people how we can improve our design". The students especially welcomed the possibilities provided by the technologies that enabled them to see how their peers had navigated their web pages and to hear their comments at the same time. One student wrote in the reflection, "my partner and I felt that our website was easy to navigate and clear to understand". However, having watched how their peers used their pages, "it became clear that our site was a little more convoluted than we had first thought, and we had the advice we needed to create a more successful web page". This comment was echoed by another pair of students, "by watching and listening to them as they navigated our website, it was easy to see the confusion we caused through our instruction and the way we designed the page". "Most of the peer feedback we received helped us to rectify issues that students might face when navigating there way through our webpage", said another pair of students.

The design process seemed also have deepened the pre-service teachers' understandings of the affordances of the Internet technology, and better understanding have apparently made them to think more about how such technology may be used to improve their teaching practices. One of the frequently reported experiences by the students was their changed views of how the Internet should be used in teaching/learning process. One student wrote in the reflection, "My previous understanding of web-based learning was merely to use a search page as a means of research to complete paper-based activities but with my understanding of web 2.0 I now know that this is undervaluing a very useful tool of critical and reflective learning. I also can see that students would feel critically engaged and in control of such activities which would foster their drive to learn". Perhaps the most important outcome of the learn-technology-by-design project was the fact that some pre-service teachers experienced conceptual change and become more positive about technology integrations in the classroom. One student pointed out that the specific strategies experienced in the collaborative design and peer evaluation could be used in their future classroom "as one way to engage students".

References

- Anderson, T. (2003). Modes of interaction. In M.G. Moore & W.G. Anderson (Eds.), *Handbook of distance education*. (pp. 129–144) Mahwah, NJ: Lawrence Erlbaum Associates.
- Hu, C., Wong, W.Y., Fyfe, V. & Chan, H. (2010a). Use EVA to facilitate preservice teacher peer assessment. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 3257–3264). Chesapeake, VA: AACE.
- Hu, C., Wong, W.Y., Fyfe, V. & Chan, H. (2010b). Formative Evaluation via Technology-Mediated Peer Assessment. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2010* (pp. 1508–1513). Chesapeake, VA: AACE.
- Mishra, P. (2006). Technological pedagogical content knowledge: a framework for teacher knowledge. *Teachers College Records*, 108(6), 1017–1054.
- Ploetzner, R., Dillenbourg, P., Preier, M., & Traum, D. (1999). *Learning by explaining to oneself and to others*. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 103–121). Oxford, UK: Elsevier Science.
- Wong, W.Y., & Reimann, P. (2009). *Web based educational video teaching and learning platform with collaborative annotation*. Paper presented at Ninth IEEE International Conference on Advanced Learning Technologies, Riga, Latvia.

Learners' Ideas about Plate Tectonics and Collaborative Game Play

Beaumie Kim, Xueli Wang, Mi Song Kim, National Institute of Education, Singapore
Email: beaumie.kim@nie.edu.sg, xueli.wang@nie.edu.sg, misong.kim@nie.edu.sg

Abstract: This presentation discusses the students' game quest design during one of our five informant design workshops. We asked our students to come up with ideas about embodying the concept of tectonic plates in the game. We discuss their ideas around three themes (volcanic eruptions as plate tectonics; plate tectonics as power in the game; and collaboration as the game rule).

This presentation discusses learners' ideas on embodying the concept of tectonic plates in a game. We asked them to come up with their ideas during one of the design workshops, which we conducted to incorporate the voices of learners, in developing a game for learning Earth science and geography, named *Voyage to the Age of Dinosaurs* (VAD). We have been working with two Singapore secondary schools in order to develop a culturally appropriate learning design using an informant design process (e.g., Druin, 2002). One of the key intentions of the informant design workshops was to create conditions in which learners' identities would shift from being passive recipients of knowledge, to becoming empowered and acknowledged experts in their own rights. We recognized young peoples' identities as media producers (Pelletier, Burn, & Buckingham, 2010) and gamers (Duncan, 2010) outside of school, who can make references to media texts that are more appealing to them, with their own rich funds of knowledge (González, Moll, & Amanti, 2005). We expected them to foreground their voices by making links between the design tasks and their familiar texts (e.g., classroom learning, media, magazines, textbooks, gaming, family talks), in the similar sense that Lemke (2005) talks about intertextual constellation. The initial stage of the project explored learners' Earth science conceptions and how technology could support alternative ways of perceiving and understanding Earth's processes, using dinosaurs and their fossils as conceptual and motivational anchors for the learning of Earth system science. In this presentation, we discuss our participants' game design activity in one of the workshops, where they negotiated and generated various meanings including tectonic plates and identity in games and the world.

Plate Tectonics and Collaborative Game Play

During the past workshops, students have shared (and transformed) their ideas about games and learning, struggled (together with the research team) with the challenge of combining education with gaming, and positioned themselves as important informants for the development. Students' experiences as gamers, students in school, participants in our workshops, and actors in their lifeworlds all mattered in their idea generations (Duncan, 2010; Pelletier et al., 2010). Students had been working together in their four small groups, and their voices and interactions reflected the group dynamics developed. Their foregrounding of the identities as designers, gamers, and informants who provide important ideas to the research team (as opposed the passive knowledge recipients) became much more apparent. In the following, we will look at the examples from what students generated during the design session, and discuss how students might be making intertextual links.

Volcanic Eruptions as Plate Tectonics

For the ideas about plate tectonics quest, all the groups related it to the volcanic eruptions, which would make changes to the environment and the situation. From their descriptions, we could see how they conceptualized the volcanic eruptions. Two groups (Allosaurus and Barney) were suggesting that a type of man-made moving force (pushing plates by robots or a machine) would somehow make the volcanoes erupt in the game. On the other hand, Stegosaurus and T-Rex were more specific on the internal Earth processes, which were convection currents and pressure. Stegosaurus used plate movements as the context of play and imposing time limit for another quest (dinosaur capture). The drawing and "Warning!" text in

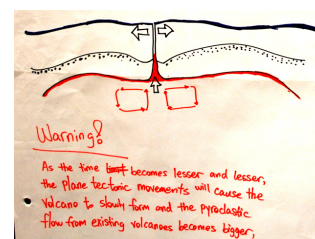


Figure 1. Plates as Context.

Figure 1 accompanied their description of how game players are supposed to bring the dinosaurs back to the future within the time limit. It reads, "As the time becomes lesser and lesser, the plate tectonic movements will cause the volcano to slowly form and the pyroclastic flow from existing volcanoes becomes bigger." In the Figure 1 drawing, they indicated movements within mantle (convection current), of magma (upward to the surface), and of plates (spreading) similar to those of oceanic ridges.

Plate Tectonics as Power in the Game

Students imagined becoming powerful through tools and environment in games, which shows the intertextuality of gaming and technology affecting their design activities. The context of the quest design, plate tectonics, became the source of power in students' designs. All the groups used plate tectonics (i.e., volcanoes) as power-

related mechanism, but the variations were in the role of volcanic eruptions: as player's means of destroying something improper, as something that should not happen (a bad guy trying to make it erupt to kill dinosaurs), or as a context that provides a further challenge to another quest. In *Allosaurus*' suggestions for this quest, they use a machine, which displays plates on Earth and clues-e.g., volcanoes at point X, Y, Z, and with which players can rearrange using + or - buttons for plates moving toward or away from each other (See Figure 2). Players would need to figure out how to create a mountain, for example, by moving specific plates in particular directions.

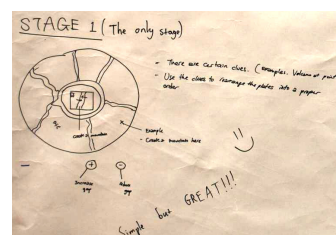


Figure 2. Plate Tectonics Machine

Collaboration as the Game Rule

The students' ideas about the quest probably reflect their cultural models about the distributed nature of the world and games: people achieve things by working with others, tools, and environment (Salomon, 1993). Their game ideas show that they could be stronger and achieve things beyond their capabilities because of other players they collaborate, tools that enable them, and the environmental limitations and/or possibilities, and that these achievements are situated in a meaningful context (for justice, for most of the groups). More importantly, players would be learning/thinking about plate movements together with the tools, the game environment, and/or other avatars. *Allosaurus* (the machine in Figure 2), *T-Rex* (the gun, pressuriser 3056), and *Barney* (the giant and powerful robot to push plates) are all focused on the use of the environment and tools, whereas *Barney* is the only group focused on working with multiple players. In *Barney*'s scenario, they suggested that multiple players should move plates together and make the volcano erupt in order to wipe out the dinosaurs supposed to be in different period from the current one (early cretaceous). They situated their knowledge about the dinosaur species and their existing eras and their ideas of plates and volcanoes in the situation and the quest objective (i.e., *To exterminate certain species of dinosaurs via volcanic eruption*). The work toward this objective is distributed among the robots (pushing power), the avatars (control of the robots, coordination among multiple robots, control of plate movement directions), the plates (destructive power, cause of volcanic eruption), and the situation (the driving force for the quest). In *Barney*'s scenario (as well as others), the distributed nature of the meaningful situation, the environment, the tool, and other players becomes the important rule of the game.

Conclusion

Students' ideas show that they are indeed experts in what would work for them as a game and how they like to learn. We could interpret above that plate tectonics, for example, should be something they can interact with (i.e., instead of static drawings), and would be most exciting to them to approach through formation and eruption of volcanoes. This workshop shows learners' ideas about different narratives, earth's phenomena, games, and their empowered roles in learning. We must highlight that they probably became more capable of drawing from their own rich funds of knowledge (González et al., 2005) through their workshop experiences. We have argued for designing learning technologies around relational meanings and emotional experiences (Kim & Kim, 2010), and students, if we listen to them carefully, are obviously advocates of our claim. In their quest designs, students positioned plate tectonics (the focus of learning content) as the mechanism for their goal achievement and the motivation for collaborations, and game player as justice-fighter who can use the power of the Earth's processes. Design and learning activities are interrelated, and in the efforts to design with learners, organizing multiple workshops with same group of students seems to be important in order for them to use their workshop experiences as their resources and to help them to become aware of their own ideas and expertise.

References

- Druin, A. (2002). The role of children in the design of new technology. *Behaviour and Information Technology* 21 (1), 1-25.
- Duncan, S. C. (2010). Gamers as designers: a framework for investigating design in gaming affinity spaces. *E-Learning and Digital Media*, 7(1), 21-34.
- González, N., Moll, L., & Amanti, C. (2005). *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. New Jersey: Lawrence Erlbaum Associates.
- Kim, B., & Kim, M. S. (2010). Distributed emotions in the design of learning technologies. *Educational Technology*, 50(5), 14-19.
- Lemke, J. L. (2005). Towards critical multimedia literacy: technology, research, and politics. In M. C. McKenna & D. Reinking (Eds.), *International handbook of literacy and technology* (Vol. 2, pp. 3-14).
- Pelletier, C., Burn, A., & Buckingham, D. (2010). Game design as textual poaching: media literacy, creativity and game-making. *E-Learning and Digital Media*, 7(1), 90-107.
- Salomon, G. (1993). No distribution without individuals' cognition. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 111-138). New York: Cambridge University Press.

Increasing Anonymity in Peer Assessment Using Classroom Response Technology

Annelies Raes, Tammy Schellens, Ellen Vanderhoven, Department of Educational Studies, Ghent University,
Henri Dunantlaan 2, 9000 Ghent,

Email: annelies.raes@ugent.be, tammy.schellens@ugent.be, ellen.vanderhoven@ugent.be

Abstract: This study explores the use of classroom response technology as a tool for anonymous peer assessment in face to face higher education. The technology was positively evaluated by students. They especially liked the immediate visual feedback and anonymity. Moreover, we found that ‘the experience of anonymity’ significantly predicts a lower ‘experience of peer pressure’. These results implicate that the use of a classroom response system can reduce peer pressure by making anonymous assessment possible.

Theoretical Background

The notion of assessment, which stresses the learning process and not only the result, is becoming more and more important in education. Different kinds of innovating forms of assessment have arisen, like self-assessment, peer-assessment and co-assessment. In this study we focus on peer assessment. Research has indicated that peer assessment assists students to create higher quality performances, as a consequence of better understanding of assessment criteria which they use when they play the role of assessors (Smith, Cooper, & Lancaster, 2002; Topping 2003). Moreover peer assessment has proven to be an accurate way of assessment, with high correlations between the ratings of peers and those of teachers (Dochy & Segers, 1999). Yet there have been some conditions put forward to guarantee this high accuracy, such as the presence of unambiguous criteria on which to evaluate (Nancy Falchikov & Goldfinch, 2000) and a necessary training in peer-assessment (Sluijsmans, Brand-Gruwel, & van Merriënboer, 2002).

Nevertheless Stepanyan, Mather, Jones and Lusuardi (2009) pointed at a disadvantage of peer-assessment. They found that students experience more stress, because they don't feel entirely comfortable with publicly evaluating their peers. Peer-pressure might also cause a lack of accuracy of the assessment (Falchikov, 2003; Sung, Chang, Chang, & Yu, 2010). In this respect, anonymity of the assessor is an important issue to consider because it is found that students are often concerned about that (Draper & Brown, 2004; Stepanyan et al., 2009). However, anonymous assessment within a face-to-face classroom setting is difficult to orchestrate whereas Stepanyan et al. (2009) pointed out that the allocation of marks and in-class activities are important in encouraging student involvement. Consequently anonymity within in-classroom peer assessment has rarely been researched. Classroom response technology, e.g. the electronic voting system TurningPoint, may provide a solution to these given objections. A classroom response system is a system used in a face-to-face setting to poll students by means of individual infrared handset transmitters. The aggregated totals of votes are displayed as immediate feedback. In this way, within peer assessment students can anonymously and immediately submit their score for every given assessment criterion. This study went into the use of classroom response technology as a tool for peer assessment and more in particular we focused on the impact of anonymity on reducing peer pressure and feeling comfortable with this kind of evaluation.

Methodology

Participants in this study were 51 third year Bachelor students in Educational Studies at Ghent University. Most of them were female (92,2%). They participated as part of an obligatory course about teaching strategies.

Students first had to formulate a set of criteria for evaluation in consultation with their teacher and then got a training in using the corresponding rubrics (score 1-5). Evaluation criteria consisted of 8 criteria evaluating didactical quality of the group presentation and 4 criteria evaluating individual performance. Students had to give a group presentations, which were evaluated by their peers using these criteria. The classroom response system, i.e. TurningPoint was used to score every criterion. Finally, a questionnaire using a 5-point Likert-scale was conducted measuring students' ‘experience of anonymity’ ($\alpha = 0.638$), ‘experience of peer pressure’ ($\alpha = 0.77$), ‘feeling comfortable’ ($\alpha = 0.76$), ‘positive attitudes’ ($\alpha = 0.84$) and ‘perception of the added value’ ($\alpha = 0.85$) of peer-assessment using the classroom response system.

Results & Discussion

Students liked the use of TurningPoint for peer assessment ($M=3.94$, which differs significantly from the neutral 3 on a 5-point Likert scale, $t(48)=11.23$, $p<.001$) and evaluated the immediate visual feedback as an added value ($M=3.98$, differs from 3, $t(48)=11.69$, $p<.001$). They also experienced the peer assessment as anonymous

($M=3.86$, differs from 3, $t(48)=9.68$, $p<.001$) and reported not to be influenced by peers ($M=2.34$, differs from 3, $t(48)=-6.45$, $p<.001$) and to feel comfortable ($M=3.84$, differs from 3, $t(48)=9.41$, $p<.001$) in scoring their peers. These results implicate that the use of a classroom response system as a tool for peer assessment can reduce peer pressure by making anonymous and immediate feedback possible in the classroom. Moreover, in a regression analysis we found that 'the experience of anonymity' significantly predicts a lower 'experience of peer pressure' ($\beta = -.51$, $t(47) = -3.45$, $p = .001$). In ongoing research, we are further examining the effects of anonymity in terms of accuracy of the scores and quality of the feedback.

References

- Bloxham, S., & West, A. (2004). Understanding the rules of the game: marking peer assessment as a medium for developing students' conceptions of assessment. *Assessment & Evaluation in Higher Education*, 29(6), 721 - 733.
- Dochy, F., & Segers, M. (1999). The Use of Self-, Peer and Co-assessment in Higher Education: a review. *Studies in Higher Education*, 24(3), 331.
- Falchikov, N. (2003). Involving students in assessment. *Psychology Learning and Teaching*, 3(2), 102-108.
- Falchikov, N., & Goldfinch, J. (2000). Student Peer Assessment in Higher Education: A Meta-Analysis Comparing Peer and Teacher Marks. *Review of Educational Research*, 70(3), 287-322.
- Pope, N. K. L. (2005). The impact of stress in self- and peer assessment. *Assessment & Evaluation in Higher Education*, 30(1), 51-63.
- Sluijsmans, D. M. A., Brand-Gruwel, S., & van Merriënboer, J. J. G. (2002). Peer Assessment Training in Teacher Education: Effects on performance and perceptions. *Assessment & Evaluation in Higher Education*, 27(5), 443 - 454.
- Smith, H., Cooper, A., & Lancaster, L. (2002). Improving the Quality of Undergraduate Peer Assessment: A Case for Student and Staff Development. *Innovations in Education and Teaching International*, 39(1), 71 - 81.
- Stepanyan, K., Mather, R., Jones, H., & Lusuardi, C. (2009). Student Engagement with Peer Assessment: A Review of Pedagogical Design and Technologies *Lecture Notes in Computer Science*, 5686, 367-375.
- Sung, Y.-T., Chang, K.-E., Chang, T.-H., & Yu, W.-C. (2010). How many heads are better than one? The reliability and validity of teenagers' self- and peer assessments. *Journal of Adolescence*, 33(1), 135-145.
- Topping, K. J. (2003). Self and peer assessment in school and university: Reliability, validity and utility. In M. Segers, F. Dochy, & E. Cascallar (Eds.), *Optimizing new modes of assessment: In search of qualities and standards* (pp. 55-87). Dordrecht: Kluwer Academic.

It's Not Only Words That Constitute Conversation - Analyzing a Collaboration Process While Reflecting

Sarah Hundertmark, Sascha Schanze, IDN, Leibniz Universität Hannover, Bismarckstr. 2, D-30173 Hannover, Email: hundertmark@chemiedidaktik.uni-hannover.de, schanze@chemiedidaktik.uni-hannover.de

Abstract: 12 learners were observed, while they were reflecting collaboratively three times in regular chemistry classroom practice, supported either by the method of computer-based concept mapping or a portfolio method. Both methods serve to help students making their thinking visible and communicable. While discussing their own ideas the students use verbal communication as well as non-verbal interaction. First results indicate differences in verbal and non-verbal communication that can be traced back to the different reflection methods.

Introduction

In order to support effective learning processes Land and Zembal-Saul (2003) describe perspectives to progressively deepen and refine meaning through a continually revision and reflection on their understanding. Therefore the students need methods or tools that help them with making their thoughts visible and communicable. Additionally, this process can be supported through collaborative learning phases as students discuss and compare their ideas (e.g. Havu-Nuutinen, 2005). We tested computer-based concept mapping (CM) as an alternative to a portfolio method called monitoring worksheet (MW). This study ties in with the research study conducted by Größ-Niehaus (2010). He compared quantitatively the influence of constructing a CM and answering a MW combined with the variable students working in pairs or working alone. The results show a) both methods (CM and MW) positively influence the development of students' understanding and b) regarding the groups „working in pairs“ no differences could be found comparing the CM and MW method. Nevertheless, further analysis of b) showed great variations. Until now the causes for the learning differences within these groups have been neglected. Consequently the focus of this study is on the following general research question: How do students learn while working collaboratively with the computer-based concept mapping method compared to those working with the monitoring worksheet?

Comparing international programs argumentation in classes is actually one popular research area. While articulating their ideas argumentatively, verbal communication as well as non-verbal interaction is essential for successful collaboration (e.g. Kumpulainen & Mutanen, 1999; Roth & Welzel, 2001). Accordingly, the focus for analyzing collaborative processes will be on subsequent question: How do differences in relation to the structure of verbal and non-verbal communication between the two groups (CM, MW) provide an indication of the diverse learning processes?

Methodology

Design and participants: The research design is based on the „case study research“ method by Yin (2003). The sample of this study originates from one grade seven chemistry course in Hanover (Germany) and consists of 12 students, six using the CM method (3 groups) and six the MW method (3 groups). The students were observed during regular chemistry classroom practice. The teaching unit comprised about 20 lessons and was divided up into three phases. After every phase the students reflected 45 minutes on the dissolution concept in order to de-contextualise the concept, as it was mediated within the context *investigating chocolate and its ingredients*. In the second and third reflection phase they got their first reflection to expand or correct it.

Data collection and instruments: In order to measure the learning progress the German version of the solution concept test (Uzuntiryaki & Geban, 2005) was used. At the end of the investigation the students were interviewed about the dissolution concept (cf. Ebenezer & Gaskell, 1995). During the reflection phases the students interactions were audio- and videotaped. Additional questionnaires controlled variables like academic self-concept or motivation.

Analysis and Results

Analysis: Yin (2003) postulates two divergent steps for an analysis. Within a deductive oriented way a simple definition of the term „discussion“ was developed from literature in order to verify whether the students argue as predicted. For an inductive oriented way the transcripts have been analyzed independently from these findings. Furthermore, the coded statements of each learner were arrayed chronologically within a flow pattern. Typical patterns of a conversation were categorized (fig. 1) and compared between the groups. As students do not only communicate verbally, the videos were analyzed according to the students' interaction.

Results: Comparing the communication time it is remarkable that the CM-groups had 81% on-topic conversation, whereas the MW-groups only had 54% of their collaborative reflection time on-topic talks. There

were some longer silent periods 35% when reflecting with MW (CM: 13%). In total the on-topic conversation time was 33 min 42sec per CM-group compared to 13min 22sec per MW-group.

The students do not argue as expected from the literature (deductive step). Argumentation structures like claim-argument-example-counterclaim-counterargument-counterexample could not be found. However, analyzing the data inductively reveals that the students use different conversation elements like claims, explanations or questions. Most frequently the element monologue was used. The CM-groups also often used confirmative elements whereas the MW-groups more often used explanatory elements. In the CM-groups the students more often refer to previous parts of the conversation (interrelation between patterns). The students were checking and resuming the links between the propositions and when revising their maps, they also made sure that their additions were correct. That was not the case in the MW groups.

With regard to their non-verbal interaction clear differences can be stated as well: students using the CM method usually supported their explanations or confirmations by pointing with the finger or mouse whereas the students using the MW in general just watch at each others MW or listened to the explanations without even looking at any of the artifacts.

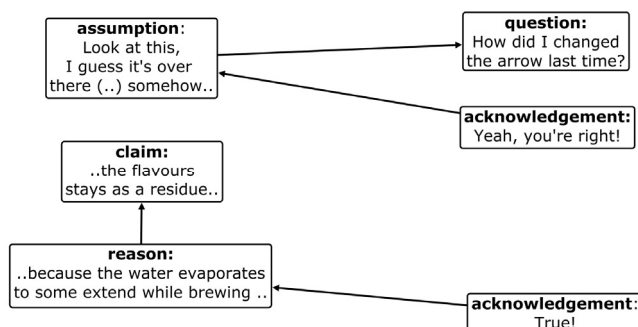


Figure 1. Extract of the Flow Pattern; Pattern of Conversation.

Discussion and Implications

With regard to the subsequent research questions structural differences of (non-)verbal interaction referring to the two groups (CM, MW) can be observed. CMs seem to facilitate the comprehension of a partners' map by reason of a multiplicity of links. However, the CM method bears the risk that students tend to accept concepts unreflectively. Debates concerning MW-texts seem to be more involving since there were more explanatory parts. Concerning the non-verbal interaction a CM is integrated more often as the students use their finger or mouse for clarifying purpose.

In general, individual learning processes can be supported by progressive reflection methods. Computer-supported and collaborating settings are promising to foster and improve students' conceptual understanding. But for making use of the beneficial features of the settings, more guidance is necessary. E.g. measures should support peer-interaction when reflecting a coherent text. Highlighting important propositions of the text could be one possible measure. On the other way support is needed that assure more reflection on the partners' propositions in the CM-groups. We expect more information when analyzing the changes made in the artifacts and correlating these changes with the conversation. Results of this study serve to promote this area of research.

References

- Ebenezer, J. V., & Gaskell, P. J. (1995). Relational conceptual change in solution chemistry. *Science Education*, 79(1), 1-17.
- Größ-Niehaus, T. (2010). Zum Verständnis des Löslichkeitskonzeptes im Chemieunterricht - der Effekt von Methoden progressiver und kollaborativer Reflexion (Vol. 102). Berlin: Logos Verlag.
- Havu-Nuutinen, S. (2005). Examining young children's conceptual change in floating and sinking a social constructivist perspective. *International Journal of Science Education*, 27(3), 259-279.
- Kumpulainen, K., & Mutanen, M. (1999). The situated dynamics of peer group interaction: an introduction to an analytic framework. *Learning and Instruction*, 9(5), 449-473.
- Land, S., & Zembal-Saul, C. (2003). Scaffolding reflection and articulation of scientific explanations in a data-rich, project-based learning environment: An investigation of progress portfolio. *Educational Technology Research and Development*, 51(4), 65-84.
- Roth, W. M., & Welzel, M. (2001). From activity to gestures and scientific language. *JRST*, 38(1), 103-136.
- Uzuntiryaki, E., & Geban, Ö. (2005). Effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. *Instructional Science*, 33(4), 311-339.
- Yin, R. K. (2003). *Case study research* (3 ed.). Thousand Oaks: Sage Publications, Inc.

Formative Evaluation of Activity Structures for a Middle School Climate Change Curriculum

Vanessa L. Peters, Nancy Butler Songer, University of Michigan, 610 East University Ave., Ann Arbor, MI, 48109 USA

Email: vlpeters@umich.edu, songer@umich.edu

Abstract: We report the results of formative evaluation of an interactive map and collaborative writing activity designed for middle-school students. An analysis of the data showed that many students had difficulties manipulating the data overlays that were an essential feature of the map activity. In addition, many students also appeared to misunderstand the intent behind the collaborative writing task. The findings have implications for the design and efficacy of CSCL-based curricular activities for middle school science.

Introduction and Background

In science education research, innovative curriculum development is often a substantial effort that spans years and requires the input of many individuals. In some cases, a project may require contributions from a team of specialists, including scientists, educational researchers and technology developers. Given the expenditure of effort and resources required for developing large-scale research-based curricula, it is important to assess the design and efficacy of activity structures while still in the formative stages of development.

Although it could be argued that most school-age children today have a fair amount of computer proficiency, few studies have specifically examined how children interact with educational technologies (Shapiro, 2008). More often than not, efforts to design computer-based learning environments have relied on developers' assumptions of how children engage with digital material (Nielsen, 2010). In education, formative evaluation is essential for structuring CSCL activities that support specific learning goals. Without it, researchers risk designing curricular materials that require students to adapt and adjust to the new technology environment, rather than designing the environment in a way that is sensitive and responsive to students' needs (Seo & Woo, 2010). By evaluating activities early in the process, researchers can capture valuable input that can inform or change subsequent design decisions (Poore-Pariseau, 2010). The goal of the current study was to identify potential problems with the structuring and design of two activity types: a beta version of a predicted distribution modeling (PDM) tool and a collaborative writing task.

Methods

Participants in the study included 84 middle school students from the United States and Canada. The mean age of the students was 11.57 ($SD = 13.77$). Data sources included an online questionnaire, students' responses to questions about a map activity, students' online edits to a peer-authored paragraph, and interviews.

Working with a software developer, we designed an interactive activity using Google maps that was a simplification of the kind of predictive distribution modeling that is central to our curriculum (Figure 1). The activity required students to click on a series of mock data overlays in order to answer questions about the map contents. Designing a usable interface was critical so students could focus their attention on understanding the meaning of the data layers, rather than focus their attention on how to go about manipulating them. Since the final activity will include overlay data that is significantly more complex (Figure 2), it was critical to learn about the difficulties students faced when interacting with this type of activity and data structuring.

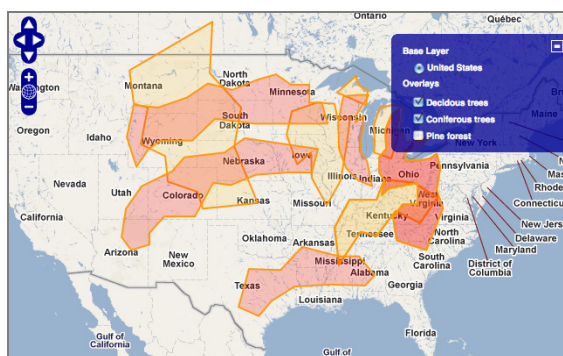


Figure 1. Mock Overlay Data for Evaluation Study.

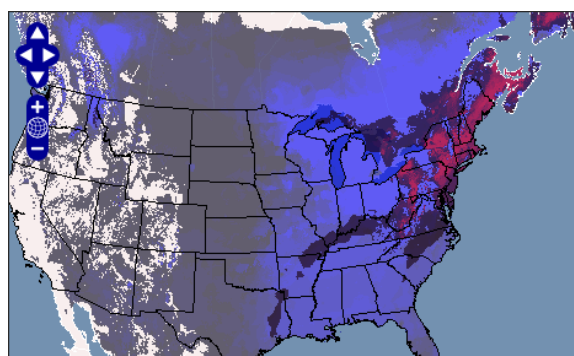


Figure 2. Authentic Overlay Data for PDM Tool.

Results and Discussion

The PDM map activity included four questions about the types of trees one could find in the United States. To

answer these questions correctly, students had to make use of colored data overlays to identify the distribution of tree types. For example, to answer the question “Can you find coniferous trees in Oregon?” students would first have to pan to the left to find the state of Oregon (all states were clearly labeled), and then resize the map with the zoom function to distinguish between state boundaries. Students would then have to click the tree data layers (deciduous, coniferous and pine forests) to determine which of those tree types could be found in the state of Oregon. A review of the responses revealed that many students answered the map questions incorrectly (Table 1). Given that all the questions were simple Yes/No questions with only one accurate response, it is probable that students had difficulties manipulating the map interface and data layers when answering questions about the tree distributions.

Table 1: Students’ responses to questions about map data.

Question	Correct Response	Incorrect Response
1. Are there deciduous trees in Texas?	43%	57%
2. Are there pine forests in Arizona?	52%	48%
3. Can you find coniferous trees in Oregon?	64%	36%

In the collaborative writing activity (Figure 3), students were asked to watch a short YouTube video commercial and then expand on a paragraph about the commercial that was written by another student. A review of the data suggests that students had difficulties interpreting the purpose and intent behind this activity. Rather than extend the ideas of the existing paragraph, 38% of students made superficial edits and 26% simply appended the paragraph with an additional sentence. Other students (22%) left the paragraph unchanged, while others (14%) deleted the paragraph and wrote something different altogether. When asked in an interview why she chose not to make any changes, one student replied: “Well, I don’t want to change what [the other student] thinks, they should be allowed to have their own opinion.”

The screenshot shows a collaborative writing activity interface. On the left, there is a YouTube video player displaying a Nissan LEAF advertisement. The video shows a light blue Nissan LEAF parked in front of a house, with a polar bear standing next to it. The video title is "Nissan LEAF™: Polar Bear" by nissanusa. On the right, there is a text editor with a paragraph of text. The text reads: "You and Becky, a 7th grade student from Toronto, have been given an assignment that asks you to write a short paragraph about the video in response to the question: 'What do you think is the message of this commercial?'" Below this text, there is a paragraph of text that has been written: "Becky decided to write the first draft, and then sent it to you for improvement. Your job is to make Becky's paragraph better by editing her text. You can add and delete any words you like, and make any other changes that you think would make the paragraph better. When you are finished, click 'Submit'." Below the text, there is a text area containing the following text: "will start melting and collapsing leaving no home for polar bears, seals and lots of other animals that live in the Arctic. The polar bear in the commercial roared at all the things that hurt his habitat. When he saw the electricity powered car the polar bear was thankful and gave the driver of the electricity car a hug. This commercial gives us a lot of messages but the most important message is not to pollute our environment." Below the text area, there is a "Submit" button.

Figure 3. Collaborative Writing Activity Based on YouTube Video.

Conclusion

The findings from this study have implications not only for our own research project, but also for CSSL research more generally. With respect to usability, both the map and collaborative writing activity presented challenges that were inherent in the design and structuring of the activity. When using the mapping tool, many students had difficulties making the connection between the physical map overlays and the data they represented – a critical distinction for using maps to answer scientific questions. In the collaborative writing activity, students seemed confused about the prospect of peer editing. In our future work, student think-alouds and focus groups are required to learn more about students’ engagement with the technology. For both activity types, carefully designed scaffolds are needed to improve not only the usability of the technology interface, but also to guide students to engage with the curriculum content – and each other – in ways that lead to improved learning.

References

- Nielsen, J. (2010). *Children’s Websites: Usability Issues in Designing for Kids: Jakob Nielsen’s Alertbox*. Retrieved November 2, 2010, from: <http://www.useit.com/alertbox/children.html>
- Poore-Pariseau, C. (2010). Online learning: Designing for all users. *Journal of Usability Studies*, 5(4), 147-156.
- Seo, Y. J., & Woo, H. (2010). The identification, implementation, and evaluation of critical user interface design features of computer-assisted instruction programs in mathematics for students with learning disabilities. *Computers & Education*, 55, 363-377.
- Shapiro, A. M. (2008). Hypermedia design as learner scaffolding. *Educational Technology Research and Development*, 56, 56-29.

A Web-based Doctoral Program to Develop Culturally Responsive Special Education Faculty

Patricia Peterson, Stephen Showalter, Northern Arizona University, Box 5774, Flagstaff, AZ 86011
Email: Patricia.peterson@nau.edu, steve.showalter@nau.edu

Abstract: To increase the number of culturally responsive special education university faculty, NAU developed distance education doctoral programs, Faculty for Inclusive Rural/Multicultural Special-educator Training (FIRST) and Leaders in Exceptional-education Addressing Diversity (LEAD). These faculty will be able to effectively address Culturally and Linguistically Diverse Exceptional (CLDE) student issues by conducting research, developing policies, and preparing special education teachers to appropriately serve the needs and ultimately improve the lives of Mexican-American and Native American students with disabilities.

Shortage of Special Education Faculty

There is a critical shortage of special education faculty in U.S. universities who are available to meet the demands of preparing special education teachers, implementing research which leads to improved practice, and developing 21st century policymakers and administrators (Dil, Geiger, Hoover, & Sindelar, 1993; Pierce, Smith, & Clark, 1992; Sindelar, Buck, Carpenter, & Watanabe, 1993; Smith, Pion, Tyler, Sindelar, & Rosenberg, 2001; Smith & Salzberg, 1994). The demand for faculty in special education in the United States is greater than the current supply of doctoral level persons available, and 30% of the university faculty position vacancies in special education go unfilled (Smith et al., 2001). In addition, Smith et al. (2001) report that since 1992, although the number of faculty vacancies has not changed, the pool of applicants to fill these vacancies is much smaller today. In special education, 255 doctorates are conferred annually, but over 50% (130) of these doctoral graduates do not become faculty members or are only in faculty positions for a short time (Smith et al., 2001).

Culturally and Linguistically Diverse (CLD) Faculty Need

By the end of this decade, the number of culturally diverse children ages 6 – 16 will have increased to 20% Hispanic, 17% African American, 5% Asian, and 2% Native American (Futrell, Gomez, & Bedden, 2003). In contrast, Futrell et al. cite the percentage of culturally diverse university faculty as only 5%. Focusing on the need for more Hispanic and Native American faculty, the National Center for Education Statistics (NCES) reports in 2001 that there were only 3.3% Hispanic and .7% Native American full-time instructional faculty and staff at U.S. colleges and universities. The Digest of Education Statistics (NCES, 2000) also reports a lack of doctorates conferred for CLD persons with only 3.2% of all doctoral degrees in 1998 for Hispanics and .5% for Native Americans. Clearly more CLD doctoral students and faculty are needed to increase the diversity in higher education compared with the growing numbers of diverse students in the school-age population. Related to the field of special education, comparatively few Hispanic and Native American students are receiving doctoral degrees. For example, in Spring 1998 Smith and Tyler (1998) report only 8 Hispanics received a doctorate in special education. Out of 1,015 students enrolled in special education doctoral programs, only 46 were of Hispanic background (Smith & Tyler, 1998). As of 2003, less than 20 Native Americans hold doctorates in special education (R. Gilmore, personal communication, January 20, 2003). It is important to increase the numbers of Hispanic and Native American faculty in special education so that they can effectively address diversity issues as well as provide mentorship to Hispanic and Native American future teachers who will in turn teach students with disabilities from Hispanic and Native American backgrounds (Dieker, Voltz & Epanchin, 2002; McSwain, 2002; Obiakor, 2001).

Rural Need

The national shortage of special education teachers and general education teachers with training in special education is especially critical in rural areas (Westling & Whitten, 1996). Izzo (1999) reported that 1/5 of all rural special education teachers will leave their jobs annually to pursue employment in larger districts and communities. Few teacher education programs focus on the preparation of teachers for rural and remote areas (Eigenberger, Sealander, Peterson, Shellady, & Prater, 2001; Helge, 1984; Helge, 1991; Heimbecker, Medina, Peterson, Redsteer, & Prater, 2002; Peterson, Medina, Gilmer, Prater, & Stemmler, 2002).

Doctoral Program Solutions

The FIRST and LEAD programs, funded by the U.S. Department of Education – Office of Special Education Programs, provide funding for tuition, books, travel to Flagstaff, Arizona, and family campus housing in the summer, and nominal research stipends. They also fund faculty research mentors, doctoral student mentors, and

enrichment seminars with nationally known researchers in bilingual special education. These innovative programs allow doctoral students to keep their positions in local school districts or universities during the school year while taking courses through web-based distance education. During the summers the students come to the Flagstaff NAU campus for intensive doctoral studies.

References

- Dieker, L., Voltz, D., & Epanchin, B., (2002). Report of the Wingspread Conference: Preparing teachers to work with diverse learners. *Teacher Education and Special Education*, 25 (1),1-7.
- Dil, N., Geiger, W., Hoover, J.J., & Sindelar, P.T. (1993). Available special education faculty positions in higher education. *Teacher Education and Special Education*. 16, 230-239.
- Eigenberger, M., Sealander K., Peterson, P., Shellady, S., & Prater, G. (2001) Challenges facing teacher educators in rural, remote and isolated areas: Using what we know and what we have learned. *Rural Special Education Quarterly* 20 (1/2), 13-21.
- Futrell, M. H., Gomez, J., & Bedden, D. (2003). Teaching the children of a new America: The challenge of diversity. *Phi Delta Kappan*, 84 (5), 381–385.
- Heimbecker, C., Medina, C., Peterson, P., Redsteer, D., & Prater, G. (2002). Reaching American Indian special/elementary educators through a partnership with a Navajo Nation School District. *Phi Delta Kappan*, 23, 373-378.
- Helge, D., (1984). The state of the art of rural special education. *Exceptional Children*, 4, 294-305.
- Helge, D., (1991). *Rural exceptional, at risk*. Reston, VA: Council for Exceptional Children.
- McSwain, A., (2002). The effects of multicultural and bilingual training on preservice students' self-reported level of competency. *Multiple Voices*, 5, (1) 54-65.
- National Center for Educational Statistics (2000). *The Digest of Education Statistics*. Washington, D.C.: U.S. Department of Education, Institute of Education Sciences.
- National Center for Educational Statistics (2001). *A Guide to Today's Teacher Recruitment Challenges*. Washington, D.C.: RNT, Inc.
- Obiakor, F. E., (2001). Multicultural education: Powerful tool for preparing future general and special educators. *Teacher Education and Special Education*, 3, 241-255.
- Peterson, P., Medina, C., Gilmer, J., Prater, G., & Stemmler, K. (2002) Changing the face of teacher preparation: Developing rural exceptional-educators to address multicultural students. *Journal of Borderwalking*, 5, 53-64.
- Pierce, T.B., Smith, D.D., & Clark, J. (1992). Special education leadership: Supply and demand revisited. *Teacher Education and Special Education*, 15, 175-182.
- Sindelar, P.T., Buck, G.H., Carpenter, S., & Watanabe, A.K. (1993). Supply and demand of leadership personnel in Special Education: A follow-up study with analysis of failed searches. *Teacher Education and Special Education*, 16, 240-248.
- Smith, D.D., & Salzberg, C. (1994). The shortage of special education faculty: Toward a better understanding. *Teacher Education and Special Education*, 17, 52-61.
- Smith, D.D., Pion, G., Tyler, N. C., Sindelar, P.T., & Rosenberg, M.S. (2001). The shortage of special education faculty: Why it is happening, why it matters, and what we can do about it. Washington, D.C.: U.S. Department of Education, Office of Special Education Programs Division of Research to Practice.
- Smith, D.D., & Tyler, N.C. (1998). *The doctoral pipeline: It's ebb and flow*. OSEP Leadership Conference Monograph.
- Westling, D.L. & Whitten, T.M. (1996). Rural special education teachers' plans to continue or leave their teaching positions. *Exceptional Children*, 62 (4), 319-335.

Tabletop Teaching Simulation: Collaborative Multivoiced Simulation for Improving Lesson Plans in Pre-service Training

Toshio Mochizuki, Senshu University, 2-1-1 Higashi-mita, Tama-ku, Kawasaki 214-8580 Japan, tmochi@mochi-lab.net

Hiroshi Sasaki, Kobe University, 1-1 Rokkodai-cho, Nada-ku, Kobe 657-8501 Japan, sasaki@kobe-u.ac.jp

Yoshihiko Kubota, Joetsu University of Education, 1, Yamayashiki-machi, Joetsu-shi 943-8512, kubota@kubota-lab.net

Hideyuki Suzuki, Ibaraki University 2-1-1, Bunkyo, Mito, 310-8512 Japan, hideyuki@suzuki-lab.net

Abstract: This paper describes a tabletop teaching simulation system to help pre-service teachers create and revise their lesson plans from the perspective of learners in a school classroom. Pre-service teachers collaboratively simulate possible lectures on the tabletop, imagining various voices of learners and using puppets attached with AR markers. The simulations can be recorded, enabling pre-service teachers to consider in depth improvements to the lesson plan, as well as being used for careful review after the simulation.

Introduction

Learning how to create lesson plans is an important part of teacher education before pre-service training internship. While planning lessons, teachers should consider not only the instructions given to the learners, but also the possibility of refutations from them. Teachers are also required to design effective questions and predict their possible answers, and encourage students to engage in inquiry-based learning.

This process can be explained using Bakhtin's theory of dialogism - every utterance made by a speaker can be considered a direct/indirect answer to a possible question by the audience. For example, a speaker anticipates possible refutations from the audience by calculating the listeners' backgrounds, previous utterances, and attitudes towards the on-going speech. The speaker then organizes his/her speech to avoid the refutations (Wertsch, 1991). In this way, the speaker's utterance is a response to previous utterances; therefore, the utterance is embedded in a dialogic relationship. For Bakhtin, the speaker's partner in the dialogue is an imaginary audience whose cultural and collective sensibilities - such as common sense, age groups, and nationalities - are taken into account (Bakhtin, 1986). Wertsch calls this characteristic "multivoicedness" (Wertsch, 1991). Meanwhile for the audience, understanding a multivoiced utterance is also a multivoiced process. According to Bakhtin, understanding an utterance involves an attempt to find "counter words" (such as questions, understanding, or criticism) in order to respond to the speaker's utterance. Through this conversation - conducted using "counter words" and the speaker's voices - the meaning of the speaker's utterance is negotiated and then determined (Bakhtin, 1986). Generally, only the teacher talks to the learners in a lecture-style teaching - rather than engaging them in a conversation. However, Bakhtin considers such a one-way speech to also be a conversation with the audience. According to this viewpoint, even in a one-sided lecture, the teacher's utterances are considered responses to possible reactions by learners; if the answers satisfy the needs and questions of the learners, then the content of the lesson is better understood. Therefore, when creating lesson plans, focus should be placed on stimulating interactions between learners and teachers by predicting the learners' reactions to the instructions; accordingly, the creation of a lesson plan must involve multivoiced planning.

Hence, developing an appropriate lesson plan based on assumed perspectives of the learners is especially difficult for novice and pre-service teachers. This is especially with undergraduate students, who have had few opportunities to participate in actual classroom lessons; it is difficult for them to create interactive lesson plans that are composed of appropriate questions and answers between the learners and teachers.

Microteaching is widely recognized as a useful method for understanding the multivoiced perspective of learners. However, reactions and feedbacks provided by colleagues acting as learners are sometimes out of context - as pre-service teachers must play the role of a much younger pupil. Furthermore, their reactions and feedbacks cannot be ensured to be serious, honest, or realistic due to embarrassment or hesitation. Thus, microteaching cannot directly improve a pre-service teacher's ability to imagine possible learner reactions.

Cartoon-based teaching simulation (Mochizuki, et al. 2010) is another means to help pre-service teachers imagine concrete conversations among the learners and teachers in an actual classroom scenario based on their lesson plans. This simulation asks pre-service teachers to present their lesson plans in the form of a cartoon. An actual implementation in a pre-service training showed that pre-service teachers could externalize their planned lesson in a more concrete way using cartoon characters playing the roles of various learners, and could reflect on their lesson plans from the perspective of the learners. However, some pre-service teachers could not generate appropriate dialogues among the learners and themselves because the dialogue was *internally* conceptualized by the pre-service teachers, based on experiences from their own schooldays.

Multivoiced Collaborative Teaching Simulation using Tabletop Technology

We propose the tabletop teaching simulation system where, through a puppet show in a miniature classroom, the pre-service teachers will be able to act as learners and teachers much more seriously, honestly, and realistically; hence represent imagined voices and the relations among the learners with greater accuracy.

Originally, Sakamoto (1980) developed the “Desktop teaching simulation game” that took place in a miniature classroom on a paperboard with puppets - consisting of a teacher, ten to twenty learners, and several paper devices such as desks, chairs, and other necessary tools in the classroom. The teacher's and learners' behaviors were acted out verbally and non-verbally by the players. Players taking the learners' roles acted simultaneously, and operated a few puppets each. Sometimes they were expected to let the learner puppets behave problematically. If someone felt the teacher's instructions had problems, the game may be interrupted to discuss improvements of the teacher's and pupil's actions as well as the overall lesson plan.

On the other hand, our new tabletop teaching simulation has been developed using tangible technology. As shown in Figure 1, the tabletop classroom is designed on a transparent desktop. An AR (Augmented Reality) marker is attached to the bottom of each puppet and device to identify the actors and furniture in the classroom. A webcam is installed under each tabletop classroom to capture and record each marker's movements and players' voices. The players can replay the recorded simulation on a Flash player, and discuss how to improve the teacher's and learners' activities in the lesson procedure.



Figure 1. Pre-service Teachers' Activities and Reflection Using the Tabletop Teaching Simulation.

There are three significant advances in the tabletop teaching simulation from previous methods. First, as a result of the participants substituting puppets to play the roles of potential learners (Klopfer, 2008), this simulation can reduce the participants' embarrassment or hesitation as seen in microteaching and create realistic responses in the classroom. Second, this simulation can deepen a pre-service teacher's insight by having them consider the voices of various learners, and by sharing those perspectives. Creating multivoiced lesson plans requires an in-depth prediction of various learners' voices based on personal values and backgrounds of the pre-service teachers; in other words, it is difficult for novice and pre-service teachers to predict a variety of learner's voices due to lack of sufficient experiences or deep insights in actual classrooms. However, in this kind of collaborative simulation, pre-service teachers can be made aware of various learners' perspectives by sharing pupils' voices from the pre-service teachers' colleagues. Third, the simulations can be recorded - enabling pre-service teachers to consider in depth improvements to the lesson plan, as well as being used for careful review after the simulation. To improve lesson plans effectively, it is important for pre-service teachers to clearly externalize their lesson plans in the form of a puppet play that depict conversations among the teacher and learners, and critique with each other. Furthermore, careful examinations of the recorded simulations act as an important catalyst for the pre-service teachers to consider deeply about designing the overall conversation in the classroom to achieve the educational goal. Records of the puppet play allow pre-service teachers to ask their colleagues for feedback regarding both their lesson plans and actions in the simulation. The feedback can give the pre-service teachers further insight about possible learner reactions.

References

- Bakhtin, M. M. (1986). *Speech genres and other late essays* (C. Emerson & M. Holquist, Eds.; W. McGee, Transl.). Austin, TX: University of Texas Press. (Originally published in 1979)
- Klopfer, E. (2008). *Augmented Learning: Research and Design of Mobile Educational Games*. Boston: The MIT Press.
- Sakamoto, T. (1980). Development and use of desk top teaching simulation game. In P. Race & D. Brook (Eds.) *Perspectives on Academic Gaming & Simulation 5 - Simulation and Gaming for the 1980* (pp. 150-160), London: Kogan Page
- Mochizuki, T., Kubota, Y., & Suzuki, H. (2010). Cartoon-based Teaching Simulation for Reflective Improvement of Lesson Plans in Pre-service Teacher Training. In D. Gibson & B. Dodge (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 1983-1990). Chesapeake, VA: AACE.
- Wertsch, J. V. (1991). *Voice of mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

My-Pet-My-Quest: Using Authoring Tool in Open Content Environment to Extend Learning Quests

Charles Y. C. Yeh, Zhi-Hong Chen, Calvin C. Y. Liao, Tak-Wai Chan, Graduate Institute of Network Learning Technology, National Central University, Taiwan

Email: Charles@cl.ncu.edu.tw, Hon@cl.ncu.edu.tw, Calvin@cl.ncu.edu.tw, Chan@cl.ncu.edu.tw

Abstract: In this paper, we describe an Authoring tool to help users sharing their learning content and design quest in an open content environment. Authoring tool is a quest editing tool which can help users to design materials and scripts in the quest easily. In the My-Pet-My-Quest system, game quests play a significant role in guiding players to accomplishing tasks. Therefore, we transform the Authoring tool into an opened content model to collect more useful materials and produce a large number of tasks. Open content environment also can maximize the educational values of learning content and stories in the quest.

Introduction

Digital game-based learning has attracted many researches interest. Game-based learning environments can inspire students to learn, and provide students with a great deal of learning opportunities to improve their learning (Gee, 2003). In addition, many researches have shown that game-based learning has positive effects on student's spatial abilities and attention (Barlett, 2009). Therefore, we design a game-based learning environment with pets, entitled My-Pet-My-Quest system, to help students learning based on the impact of pets (Chen, 2009). Students will play the role of pet-trainer who can interact with My-Pet that sustains his/her motivation and engage him/her in learning tasks and competition activities (Liao, 2009). Our research shows that quests and scripts design is the most significant two factors in the quest-driven learning content. Thus, how to maximize the educational values of learning content and stories in the quest design and how to balance learning subjects and learning content in the quest design is very important.

In this paper, we want to extend our developing quest tool, which called Authoring tool, to facilitate users sharing their learning content to achieve student-centered learning and let students learning by doing in an open content environment.

My-Pet-My-Quest System

A My-Pet-My-Quest includes three main parts: fostering pets, accomplishing learning quests (playing small games which included learning content) and getting rewards. In the My-Pet-My-Quest, students mainly interact with NPCs (Non-Player Characters). An information provider NPC would invite the pet-keeper and request for help. It then tells the pet-keeper information about the quest, such as quest content, condition, and rewards. The pet-keeper needs to go to somewhere to find another quest-giver NPC in the environment for accepting the quest and to help the quest-giver NPC (to complete the quest) then get the rewards. Figure 1 shows the snapshot of the quest by information provider NPC. The NPC tells the pet-keeper that have some events require players to help. Pet-keeper can go to the location which told by quest-giver NPC to start quests, the quest content may contain language, mathematics or problem solving. Pet-keeper must complete the mission condition (e.g., speed or accuracy of the questions, etc.) for the quest rewards.



Figure 1. Snapshot of the Quest Delegated by the Information Provider NPC.



Figure 2. An Example of a Quest.

The Authoring Tool

This study has developed a simple quest edit tool which called Authoring tool (Shown as Figure 3 and 4). Authoring tool mainly provide four functions: edit quest content, add new quest, and edit scripts, quest setting

and management. Authoring tool allows users to easily design a new quest, create a script, replaced learning content, and setting reward. The main purpose of Authoring tool is to make user through this tool to design task and learning content. The user maybe a student also can be a teacher. Users through the tool can completely self-made question, script, learning content and select the corresponding NPC. User also can choose from an online library to get some question or script which from other experts or teachers. Teaching (which may be teachers or students) not only make the task easier but also can set appropriate learning tasks and objectives. Open content model can maximize the educational values of learning content and stories. The content was provided by many users that maybe a teacher or expert. It also supplies an opportunity of students to construct their own knowledge by design content. Balance learning subjects and learning content will be possible to achieved because open content design by these professions.

編號	類型	名稱	說明	npc	條件說明	條件	獎勵說明	獎勵類型	獎勵數量	任務選取	觸發地點	任務系列
1	主線任務	按力發功發	只要通過牛	村民	達成90%	80	等級+1	exp	250	forest	1	數學球力量
2	主線任務	按力發功發	只要通過牛	村民	達成90%	80	等級+1	exp	150	forest	1	數學球力量
3	支線任務	牛刀小試	動物森林裡	村民	達成90%	80	經驗20元	money	20	forest	1	數學球力量
4	支線任務	動物森林裡	動物森林裡	村民	達成90%	80	經驗20元	money	20	forest	1	數學球力量
5	支線任務	按力發功發	今天發功發	村民	達成90%	80	經驗+1	exp	150	forest	1	數學球力量
6	支線任務	動物森林裡	動物森林裡	村民	達成90%	80	經驗20元	money	20	forest	1	數學球力量
7	支線任務	高斯的地點	動物森林裡	高斯	達成90%	80	等級+1	exp	150	forest	1	管帶的經驗
8	支線任務	高斯的地點	動物森林裡	高斯	達成90%	80	經驗20元	money	20	forest	1	管帶的經驗
9	支線任務	牛刀小試	動物森林裡	高斯	達成90%	80	等級+1	exp	0	forest	1	管帶的經驗
10	支線任務	美奧王的地	動物森林裡	高斯	達成90%	80	經驗20元	money	20	beautyFar	1	管帶的經驗
11	支線任務	美奧王的地	動物森林裡	高斯	達成90%	80	經驗20元	money	200	middleppn	1	管帶的經驗
12	支線任務	美奧王的地	動物森林裡	高斯	達成90%	80	經驗20元	money	100	fish	1	管帶的經驗
13	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	等級+1	exp	150	forest	1	管帶的經驗
14	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	經驗20元	money	20	forest	1	管帶的經驗
15	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	等級+1	exp	150	papa	1	森林任務
16	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	經驗20元	money	20	papa	1	森林任務
17	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	等級+1	exp	150	papa	3	森林任務
18	支線任務	美奧王的地	動物森林裡	高斯	達成90%	85	經驗20元	money	20	papa	3	森林任務

Figure 3. Snapshot of the Authoring Tool.

Figure 4. Function of Assign Quests to System.

Conclusion and Discussion

My-Pet-My-Quest used in an elementary school to help students learning mathematics now. We wish to extend the editing tools into an open content environment to be more application. Open quest environment will collect all created quests and materials into library that can give the other one use and provide their teaching methods. Quest created by teachers or students are more appropriate for their own curriculum. Students edit the script of the quest and exchange task learning materials can be achieved "learning by doing". Quest design by teachers or students not only can truly achieve student-centered learning but also reach a long-term, more sustainable, and more appropriate for students. Finally, we hope that students can edit good stories and creative content and construction their knowledge by design quest.

Open content model may have some problems: (1) someone shared the incorrect or inappropriate materials (2) teachers or students were reluctant to use this tool. If student create a wrong or indecent quest that must be deleted or edited by administrator or system. The management problem may increase system and teachers burden. Another problem is users didn't want change the existing pattern to use the tool. However, open content model is a solution to expand learning materials and reach a long-term learning in My-Pet-My-Quest system.

References

Barlett, C. P., Anderson, C. A., & Swing, E. L. (2009). Video Game Effects—Confirmed, Suspected, and Speculative: A Review of the Evidence. *Simulation & Gaming*, 40(3), 377-403.

Chen, Z. H., Liao, C., Chien, T. C., & Chan, T. W. (2009). Animal companions: Fostering children's effort-making by nurturing virtual pets. *British Journal of Educational Technology*. doi: 10.1111/j.1467-8535.2009.01003.

Chen, Z. H., Tseng, Y. F., Liao, C. C. Y., & Chan, T.W. (2009). My-Pet-My-Quest: Utilizing Game Quests to Scaffold Students Goal Setting for Learning. The 17th International Conference on Computers in Education.

Gee J. P. (2003). What video games have to teach us about learning and literacy. Palgrave Macmillan, New York.

Liao, C. C. Y., Chen, Z. H., & Chan, T. W. (2009). Designing the game-based environment to facilitate learners' interaction in performance-based learning by virtual pets. *In Proceedings of the 9th international conference on Computer supported collaborative learning - Volume 1* (pp. 429-433). Rhodes, Greece: International Society of the Learning Sciences.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financial support (NSC-99-2631-S-008-001) and (NSC-99-2511-S-008-002).

PreK Teachers & Students Using Multi-touch Virtual Manipulatives: An Analysis of Usability and Learner-centered Design

Michael A. Evans, Department of Learning Sciences and Technologies, Virginia Tech, Blacksburg, VA, 24061 USA, mae@vt.edu

Jeremy Crider, Department of Computer Science, Virginia Tech, Blacksburg, VA, 24061 USA, crider12@vt.edu

Andrea Motto, Department of Teaching and Learning, Virginia Tech, Blacksburg, VA, 24061 USA, andreamotto@vt.edu

Adrienne Brunger, Department of Mathematics, Virginia Tech, Blacksburg, VA, 24061 USA, abrunger@vt.edu

Jesse L.M. (Jay) Wilkins, Department of Teaching and Learning, Virginia Tech, Blacksburg, VA, 24061 USA, wilkins@vt.edu

Abstract: For the reported work we focus on several iterations to refine a tangram application for a multi-touch, multi-user interactive surface, the SMART Table™ by SmartTech. We recruited one PreK teacher and six students (ages 4 to 5) from the university's child development center to capture usability data and reactions to design choices. Preliminary findings have guided development to support research into the socio-cognitive parameters of collaboration while exploring the limitations of the commercial technology to support CSCL.

Overview

Our agenda is motivated by the construct of group cognition (Stahl, 2006) as a means to develop applications under the rubric of computer supported collaborative learning (CSCL). Contributions to CSCL are highlighted by interests in advances in early childhood mathematics education, and the design of virtual manipulatives for multi-touch tabletop computers. We report on recent iterations of a tangram application for the SMART Table™ that supports collaborative, co-construction of mathematical thinking in PreK students (ages 4-5).

Initial Investigation with Physical & Virtual Manipulatives

Participants. For the purposes of this design experiment, participants were one teacher, three girls and three boys from a PreK child development and learning research center at a large, mid-Atlantic university in the United States. However, during the virtual phase of the study, only two of the three girls were present due to fluctuations in summer attendance at the center. Thus, for the girls' virtual stages of this study, the child C position was eliminated. *Setup.* Video equipment, consisting of two cameras, was set up to capture both the students' faces and the students' hands (Figure 1a). Next, a SMART Table, a multi-touch, multi-user surface, was placed in the center of the room, students being arranged around it (Figure 1b).



Figure 1. a. Set-up of Research Facility; b. Completing "Bear" Puzzle; c. Fisherman Puzzle, Divided Ownership.

The tangram puzzles selected were developed using Clements's et al. (2004) learning trajectory. For the first set of puzzles (those completed during the physical phase of the study), some regions consisted of only one tangram piece while others regions consisted of several. Furthermore, as students became familiar with transformational geometry tasks, they appeared to exhibit higher levels of thinking along the learning trajectory (Clements, et al., 2004). *Procedure.* Data collection for this study took place in five stages for the physical phase and four or five stages for the virtual phase, for the girls' group and the boys' group, respectively. Prior to the beginning of each stage, the rules for tangrams were explained or reviewed and pictorial representations of these rules were posted. Social constraints (*free ownership*, *divided ownership*, and *single ownership*) were implemented verbally and participants each received a cue card with her "role" on it. The card reading "touch"

meant that the participants were allowed to touch any and all of the tangram pieces, the card reading “helper” signified that the participants could guide tangram placement but not actually touch the pieces, and the red, green, and blue cards indicated which color tangrams were touchable.

Virtual Manipulatives as a Basis for Usability

The initial implementation offered little more than the translation and rotation of tangram pieces and the outline of the puzzle to complete. The application produced unexpected side effects such as the *tornado effect* where low virtual friction of each piece caused effortless rotation and flicking. As a result, students diverted their attention from the completion of the puzzle, prohibiting useful data. Increasing the friction of the pieces prevented flicking and in turn stopped the tornado effect. The absence of a locking mechanism made it difficult for students to complete puzzles as pieces could be accidentally moved or intentionally stolen by other students. Rather than use the automatic locking mechanism aforementioned, we designed a behavior based locking system that required students to commit to a placement before locking a piece into position. This led to a question of what gesture best described the locking effect. We first implemented a locking behavior in which a single finger holding on top of a piece with no movement for a short period of time initiated the lock. Field tests resulted in frustration as users might activate the lock with little movement. The second implementation of a locking feature employed a more natural locking behavior based on an unsticky sticker concept: applying extra pressure to a piece activates the locking mechanism. In the implementation of the locking features in general, locking large tangram pieces on top of smaller pieces caused pieces to be misplaced due to occlusion. To make the pieces always visible, we modified the outlines and opacities. In several trials we found that students became impatient when unable to complete the puzzle after several minutes and simply gave up. To virtualize the idea of giving students hints, we designed and implemented a hinting system based on unanimous vote. The voting system was employed to allow a single user, who did not want a hint, to cancel the vote. In previous designs, social constraints for the puzzle were implemented using cards given to the children. One card contained a single rule and another card denoted the color that the rule applied to. We designed and implemented a new rule system that removed the physical cards by virtualizing and combining both rules and colors. With a simple press of a rule, it displays a label reminding the learner of their personal constraints.

Drawing on Informal Geometry Pedagogy to Drive Evidence-based Design

In solving puzzles through play, learners are able to manipulate pieces and think about the shapes, their attributes, and their position relative to the final puzzle. Through social interaction children are able to talk about the pieces that allow them to further develop their geometric language. To promote social interaction, the latest build supports three different scenarios or constraints for each puzzle given: free, single and divided. Each of these scenarios provides the learner with a unique experience that promotes cooperation allowing learners to take the opportunity build necessary social skills through collaborative reasoning. In the free ownership mode, we allow learners to move any of the pieces they see fit in order to complete the puzzle. In divided ownership mode, we separate the pieces into three different colors, one for each learner. In each of the modes, we encourage learners to talk with each other to complete the puzzle. In the single ownership mode, we allow a single learner to move any of the pieces while the other two learners assist in moving the piece using gestures and dialog. Each mode, particularly single ownership, relies on speech and gesture to complete the puzzles.

Conclusion

As Bjuland et al., (2009) state: “Collaborative mathematical reasoning cannot be fully captured by only paying attention to what they write and what they say...pupils use the modalities of speech, gesture, and writing to solve the mathematical tasks” (p. 290). From recent findings examining talk, gesture, and gaze, we are developing future applications for the SMART Table that support group cognition via collaboration and co-construction. A design experiment approach ground the research in the local context and contingencies.

References

- Bjuland, R., Luiza C., M., and Borgersen, Hans E. (2008). The Interplay between gesture and discourse as Mediating Devices in Collaborative Mathematical Reasoning: A Multimodal Approach", *Mathematical Thinking and Learning*, 10(3), 271-292
- Clements, D., Wilson, D., & Sarama, J. (2004). Young children’s composition of geometric figures: A learning trajectory. *Mathematical Thinking and Learning*, 6(2), 163-184.
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Acknowledgements

National Science Foundation (Awards 0736151, 0832479); SMART™ Technologies

Designing Course Management System into CSCL Tools: Experience with Moodle

Jingyan Lu, Nancy Law, Faculty of Education, Pokfulam Road, The University of Hong Kong, Hong Kong
Email: jingyan@hku.hk, nlaw@hku.hk

Abstract: Course management systems (CMSs) were originally designed for teachers to manage their teaching, little interest has been directed at students' learning. Moodle is a CMS. This study investigates two features, wiki and assessment tools embedded in the Moodle system as to how they are designed to support project based learning. The effects of wiki-supported collaboration, peer grading and feedback on junior secondary students' enquiry on liberal studies are analyzed using multiple regression.

Introduction

As teachers increasingly use Course Management Systems (CMSs) to design more hybrid learning activities, students engage in more online learning. It is therefore of interest to investigate and identify patterns of students' online learning behaviors and to assess their impact on learning performance. Recent developments in the design of CMSs have expanded their scope and incorporated such principles. Moodle makes available many web-based applications, we will focus on two: wikis and peer assessment tools. We focused on investigating two student learning activities on Moodle: collaborative knowledge construction and peer assessment. We examined how students use wikis to co-construct knowledge and assessment tools to evaluate each other's work. Wikis allow incremental knowledge creation and enhancement (Cole, 2009), impose no pre-defined structures unlike blogs (Bryant, 2006) and are easy to use (Ebersbach, 2008). When learners evaluate each other's work, they increase their awareness of the criteria for quality work in a subject domain. As a result, they reflect on and become more attentive to applying these criteria to their own work. Web-based assessment tools were also found to facilitate learning by facilitating giving and receiving peer feedback (Tseng & Tsai, 2007) and helped students observe peers' writing, identify revisions, communicate with peers, reflect on and improve their own work (Yang, in press).

Methods and Results

One hundred and eighty-six students Secondary Two students in a local Hong Kong school participated in this study. Students were from five classes and were 13-14 years old. The students worked on a Liberal Studies (LS) project on Moodle. Moodle log files which included students editing their own wikis and those of peers, submitting grades and comments to each other across the five subtasks. Assessment tools provided multi-dimensional rubrics for each subtask. Students can choose a number grade in each level. They could also write feedback (Figure 1a). Wiki helped students construct knowledge individually and collaboratively (Figure 1b)



Figure 1: Screenshot of Peer Assessment (1a) and Wiki (1b).

Hierarchical multiple regression was used to examine the effects of online behavior of knowledge construction and peer evaluation on project performance (final project score). Data from 186 students (95 girls and 91 boys) was used in the analysis. Students on average gave more grades (mean = 13.10) than feedback (mean = 8.05) to peers. They also received more grades (mean = 13.80) than feedback (mean = 9.80) from peers. The multiple regression showed the number of comments to peers ($t = 2.8, p < .01$) and number of revisions on their own wiki ($t = 3.4, p < .01$) were significant predictors to their project scores, controlling for scores on Humanities and Computer Literacy. The number of revisions to peer's wiki had a borderline effect ($t = 1.9, p < .10$).

Discussion

Students in this study used wikis to develop individual projects, to work in small groups and to make additions to each other's work. Working on their own wikis and on those of peers were significantly correlated with final

project performance. Wikis were effective in getting students to work on their own projects. The more often students revised and updated their work, the better their final project grades. How often students collaborated on the wikis of peers had a significant effect on their own project. The results implied that CSCL environments should be designed to promote agency and collective cognitive responsibility. A certain level of agency determines the level of collective cognitive responsibility which in turn promotes higher levels of agency. Wikis as CSCL tools promotes higher levels of agency among users in managing their engagement with resources and peer users.

Online assessment includes giving and receiving grades and feedback. The more feedback learners provided to peers, the better their own project performance. A possible explanation could be that when learners assess peers, they engage in activities with different cognitive demands. It could be that by assessing the projects of peers, learners became more critical and effective as they develop a clearer understanding of the topic under review and the application of the assessment criteria, which in turn, have a great influence on their own work. Although, peer assessment is a well recognized and important pedagogy it is not regularly implemented because assigning peer work, asking for peer grading and feedback, and giving back peer assessment work in paper format is often difficult. Online assessment tools can simplify and operationalize peer assessment. Students are able to give comments and make them immediately available to peers.

This study implies that 1) while most learning technology emphasizes self-assessment and reflection, easy to use CSCL tools should also be designed for the CMC to facilitate peer assessment and reflection. 2) While wikis are commonly used to support collaborative learning and knowledge construction, peer assessment tools are seldom used in conjunction to support the learning process. The findings from this study indicate that when integrated into a CMS to support learning such tools can enhance the pedagogical value of wikis.

References

- Bryant, T. (2006). Social software in academia. *Educause Quarterly*, 29(2), 61-64.
- Cole, M. (2009). Using Wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141-146.
- Ebersbach, A. (2008). *Wiki: Web collaboration* (2nd ed.). Berlin; New York: Springer.
- Tseng, S. C., & Tsai, C. C. (2007). On-line peer assessment and the role of the peer feedback: A study of high school computer course. *Computers & Education*, 49(4), 1161-1174.
- Yang, Y.-F. (in press). A reciprocal peer review system to support college students' writing. *British Journal of Educational Technology*.

Acknowledgement

This research is funded by Quality Research Fund (QEF) by Hong Kong Government to the second author. We would like to thank our colleagues at the Centre for Information Technology in Education (CITE) of the University of Hong Kong: Dr Lee Yeung, Dr Lee Man Wai, Mr Andy Chan, and Mr Murphy Wong for their technical support and assistance in data collection.

Computer Support for Collaborative Reflection on Captured Teamwork Data

Kristin Knipfer, Knowledge Media Research Center, Germany, k.knipfer@iwm-kmrc.de
 Michael Prilla, Institute for Applied Work Science, University of Bochum, michael.prilla@rub.de
 Thomas Herrmann, Institute for Applied Work Science, University of Bochum, thomas.herrmann@rub.de
 Ulrike Cress, Knowledge Media Research Center, Germany, u.cress@iwm-kmrc.de

Abstract: We describe the significance of collaborative reflection for team learning at the work place and present accounts for computer-supported reflection on joint teamwork. These solutions provide support for collaborative knowledge construction and meaning making based on captured teamwork data. They include support for articulation work and adapt recent accounts of scaffolding and guidance to the generic scope of team reflection at the workplace.

The Significance of Reflection for Team Learning at the Workplace

Reflection on one's own work practice has been identified as one of the central mechanisms of learning at work (Argyris & Schön 1996; Boud, Keogh, & Walker, 1985; Dewey 1933; Kolb & Fry 1975). It leads to a better understanding of own work practice and work-related experiences and can guide future behavior (Järvinen & Poikela, 2001; Moon, 1999). As most business organizations have implemented *teams* to face successfully the challenges in business life, we argue that research should consider *team learning by collaborative reflection on joint work* more thoroughly. The social dimension of reflection has recently been described by Dyke (2006), who highlights the role of sharing experiences for the purpose of learning (see also Hammond & Collins, 1994 and Orton, 1994). Joint discussion on experience is considered to stimulate and deepen individual reflection and to enable creative solutions. Recent definitions of team learning thus include the notion of reflection explicitly (e.g., Edmondson, 1999). In this context and in accordance with constructivist theories of cognition, learning is considered to occur as collaborative construction of knowledge (Roschelle & Teasley, 1995). In particular, the process of co-constructing knowledge leads to a deeper insight into a situation or problem, enabling the creation of new and well-grounded knowledge on the group level. This corresponds with the fact that reflection is often accomplished collaboratively by a team or working unit and based on sharing work-related experience. We consider collaborative reflection as an emergent phenomenon in which a shared understanding about work practice is established in an team, allowing for learning from past experiences. The availability of shared material which mirrors recent work practices serves as a catalyst and basis for this mutual reflection and sense making. The research described in this paper as well as the design and the implementation of corresponding tools is embedded into the project *MIRROR - Reflective Learning at work*, which aims at engaging employees in reflecting on their own work practice and specific work-related experiences in order to learn from it.

Designing Computer Support for Collaborative Reflection

While many concepts such as scaffolding and guidance have been shown to be beneficial in educational settings (cp. Jermann, Soller, & Muehlenbrock, 2001; Stahl, Koschman, & Suthers, 2006; see also Carell & Herrmann, 2009; Carell, Herrmann, Kienle, & Menold, 2005; Cress & Kimmerle, 2008; Herrmann & Kienle, 2008), little is known on their application in the workplace setting. There, teamwork refers to aspects of team effectiveness with regard to the task the team is required to achieve. This usually has nothing to do with learning in the first place. However, team learning is strongly interrelated with task performance if we consider that learning from past teamwork experiences is crucial for enhancing future team performance (Edmondson, 1999). Team performance thus depends on a team's ability to learn from experience by means of reflection on own work practice (Kayes & Burnett, 2006). Reflection should thereby be based on material that mirrors real work practice. To support team reflection, we use an approach based on using *recorded data from team work*.

Recorded data from teamwork provides a basis for collaborative reflection on own team work and thereby enhances a team's awareness on its own work practice. However, using such data for collaborative reflection not only needs sophisticated means of gathering and aggregation of the data, but people need to be supported while interacting with this data, e.g., relating different data snippets to each other and articulating individual understandings. We argue that both gathering data and interaction with data needs a socio-technical solution in order to support collaborative reflection and knowledge construction properly. This approach has to combine organizational methods and processes with information technology and intervention strategies. We focus on the explication of experiences and reflection results by means of articulation, support for group discussion of experiences and meaning making from this shared experience as well as the convergence and construction of new knowledge.

- 1) *Articulation support:* We suggest that collaborative reflection on captured teamwork data can be facilitated by specific means to comment on such data and to support individual articulation (Suchman, 1996).

Through individual and collaborative annotations, a rich and comprehensive database to guide collaborative reflection will be made available. This will enable teams to make sense of captured teamwork data and to use it for further reflection through negotiation of individual understandings of teamwork.

- 2) *Scaffolding and guidance support*: Solutions for guiding and scaffolding will include support for synchronous and asynchronous reflection processes such as the functionality of external referencing to parts of recorded material, visualizations of the process of communication and reflection, or summaries and control of the interplay between questions, answers and arguments.
- 3) *Synergy support*: In order to help people access results and to make them sustainable, processes of convergence and the construction and explication of new knowledge have to be supported. We intend to implement voting and tagging to support structuring of reflection material and converging parts of the articulated reflection into new ideas which go beyond individual reflection.

Our research intends to provide an integrated solution for applying collaborative knowledge construction and meaning making based on captured teamwork data by supporting articulation, discursive interaction and synergizing on shared experiences. It aims at applying concepts of scaffolding and guidance for the generic scope of workplace reflection and integrating these solutions into a socio-technical framework intertwining technical support and intervention strategies. In order to accomplish these goals, further work will be focused on investigating processes of collaborative reflection and deriving potential support for it in real world settings.

References

- Argyris, C., & D. Schön (1996). *Organizational learning II. Theory, method, and practice*. Reading, MA, USA, Addison Wesley.
- Boud, D., Keogh, R., & Walker, D. (1985). *Reflection: turning experience into learning*. London: Kogan Page.
- Carell, A., & Herrmann, T. (2009). Negotiation-tools in CSCL-scenarios - Do they have a valid use? In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL2009 Conference Proceedings* (pp. 557-567).
- Carell, A., Herrmann, T., Kienle, A., & Menold, N. (2005). Improving the coordination of collaborative learning with process models. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.), *Proceedings of CSCL 2005. The next 10 Years* (pp. 18-27).
- Cress, U. & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, 3 (2), 105-122.
- Dewey, J. (1933), *How we think. A restatement of the relation of reflective thinking to the educative process*. Boston: D. C. Heath.
- Dyke, M (2006). The role of the 'other' in reflection, knowledge formation and action in a late modernity. *International Journal of Lifelong Education*, 25(2), 105-123.
- Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative science quarterly*, 44(2), 350-383.
- Hammond, M., & Collins, R. (1994). *Self-directed learning: Critical practice*. London: Kogan Page.
- Herrmann, T., & Kienle, A. (2008). Context-oriented communication and the design of computer-supported discursive learning. *International Journal of Computer-Supported Collaborative Learning* 3(3), 273-299.
- Järvinen, A., & Poikela, E. (2001). Modeling reflective and contextual learning at work. *Journal of Workplace Learning*, 13(7/8), 282-289.
- Jermann, P., Soller, A., & Muehlenbrock, M. (2001). From mirroring to guiding: A review of state of the art technology for supporting collaborative learning. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *Proceedings of the first European conference on computer-supported collaborative learning (CSCL)*, 324-331).
- Kayes, D. C., & Burnett, G. (2006, March). *Team learning in organizations: A review and integration*. Paper presented at the OLKC 2006 Conference at the University of Warwick, Coventry.
- Kolb, D.A., & Fry, R. (1975). Towards an applied theory of experiential learning. In C. Cooper (Ed.), *Theories of Group Processes* (pp. 33-58). London: John Wiley.
- Moon, J. (1999). *Reflection in learning and professional development*. London: Kogan Page.
- Orton, J. (1994). Action research for drama educators. *NADINE Journal*, 18(2), pp. 85-95.
- Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (editor), *Computer supported collaborative learning* (pp. 67-97). Heidelberg: Springer.
- Suchman, L. (1996). Supporting articulation work. In R. Kling (Ed.), *Computerization and controversy: Value conflicts and social choices* (pp. 407-423). San Diego: Academic Press.

Acknowledgement

The project *MIRROR - Reflective learning at work* is funded under the FP7 of the European (project number 257617).

Factors Affecting Students' Performance in a Supportive E-learning System — eCIS: An Exploratory Study

Ching-Huei Chen, I-Chia Wu, Graduate Institute of e-Learning, National Changhua University of Education
Email: chhchen@cc.ncue.edu.tw, wu_1225@yahoo.com.tw

Abstract: This study examined predictive relationships among high school student characteristics that influence their performance in eCIS. Correlations, analysis of variance, and path analyses were conducted. Findings indicated that individual differences on learning goals and cognitive preferences predicted their metacognitive strategy use, and later influenced the performance. Discussions on how to accommodate the different needs of students with varying levels of prior knowledge, goal orientation, and cognitive preference are provided based on the results.

Introduction

Students bring personal characteristics to the learning contexts, such as goals and varying degrees of motivation. Achievement goal orientations are normally divided into three types: learning (or mastery) and performance approach, and performance avoidance (Elliott & Church, 1997). Learning goals describe a learner engaging out of a personal desire to know and understand the content and master the skills (Ames, 1992). Performance approach goals describe a learner trying to outperform others, to look good in the face of external, social pressure and comparisons (Church, Elliot, & Gable, 2001; Greene & Miller, 1996). Performance avoidance goals describe a learner evading work or public performance to avoid embarrassment or looking incompetent to others. Learning goals are a productive, positive orientation promoting effort for all students, while performance goals have demonstrated mixed outcomes (Pintrich, Conley, & Kempler, 2003). Just as achievement goals is important to student motivation, so are students' cognitive preference. Students' cognitive preferences also influence their reception of and responses to teachers' and peers' messages regarding self-determination and goals (Reeve, 1996). One important preference is the need for cognition, which refers to a student's inclination for deep and thoughtful engagement and ill-structured problems (versus simple questions with "right" or easy answers) (Forsterlee & Ho, 1999). Students' need for cognition can influence both motivational and achievement outcomes (Greene et al., 2004).

There is a paucity of research examining these multivariate relationships, and there is still a need for more empirical evidence-based research into how individual's goal orientation influences online performance. Integrating theory from research on cognition and motivation, this research validated a model of three factors (prior knowledge, learning/performance goals, and need for cognition) that contribute to online learning and one factor (metacognitive strategy) that mediate the relationship between aforementioned factors and performance. If students are lacking one or more of these critical cognitive or motivational characteristics, they are in danger of being less than optimally motivated and engaged in the learning task (Pintrich & Schunk, 1996). Both cognition and motivation are internal processes with non-continuous behavioral indicators, it can be difficult to address. If we can better identify students' cognitive motivational needs and address them, students can learn more effectively (Hidi & Harackiewicz, 2000). However, among a vast number of studies demonstrating the importance of motivation in students' learning in both traditional and online learning environment, only a few have included high school students samples explicitly, and analyzed for cognitive and motivational differences. Fewer have focused on the outcome of these differences on actual performance as a result of e-Learning in particular, rather than students' self-report or perceived effect and none we could locate have examined differences between students' cognitive and motivational profiles on their metacognitive strategy use.

Method

Participants were 157 tenth-grade students enrolled in a physics course at a high school in a traditional vocational school in central of Taiwan. There were 138 males and 19 females with a mean age of 16.4 years. Participation in the experiment was considered a course requirement, but subjects' level of performance was not counted in determining course grades. eCIS, an electronic-based Collaborative Inquiry System, with embedded scaffolds (i.e., simulations, courseware, and instructional prompts) to support physics learning was created. eCIS database server is built using MS-SQL Server 2005, which serves as a relational database for storing users' personal and background information, courseware, testing items, simulations, inquiry prompts, and questionnaires, among others. A 14-item multiple-choice test was used to assess students' understanding of scientific concepts on percentile motion. This test has been revised numerous times according to science teacher's suggestions and pilot testing results using similar samples. Since no direct teaching was involved in this study, a gain in the performance scores would indicate that the student has acquired a good understanding of the scientific concepts after being exposed to eCIS learning system. Students' goal orientation was measured by

the Achievement Goal Orientation Inventory (Elliott & Church, 1997). The measurement comprised of three subscales of learning, performance-approach, and performance-avoidance goals, with 6 items for each goal orientation, for a total of 18 items. The 18 items utilize a 5-point scale from: 1 (strongly disagree), to 5 (strongly agree). The subscale reliabilities coefficients were as follows: learning goals ($\alpha = .85$), performance-approach goals ($\alpha = .74$), and performance-avoidance goals ($\alpha = .71$). The Need for Cognition scale was used to assess individual preference for deep thinking and ill-structured problems (versus simple questions with right answers) (18 items on a 5-point scale from Forsterlee & Ho, 1999). Sample items include: "I would prefer complex to simple problems" and "I only think as hard as I have to" ($\alpha = .84$). Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) was selected for use in this study as a primary assessment tool as it was the most widely used in many contexts, particularly those of online learning (Matuga, 2009). For this study, a modified version of the MSLQ contained 10 items from the learning strategies subscales utilizing a 5-point scale from: 1 (strongly disagree), to 5 (strongly agree). Reliability coefficients for metacognitive strategies scales were $\alpha = .82$.

Results

Based on our proposed conceptual model, we concluded with two major findings. First, goal orientation is an important motivational component for metacognitive strategy use is consistent with the results from previous studies. In that we found having learning goals was found to adopt metacognitive strategies compared to having performance goals. In terms of performance, the results did not show difference on either having learning or performance goals. Some goal theorists agreed that learning goals are beneficial for most learning-related outcomes including motivational outcomes such as efficacy, interest, and value, whereas performance goals are beneficial for achievement. Second, need for cognition is an important motivational component for metacognitive strategy use. We found that high need for cognition students performed significantly higher than low need for cognition students. We speculate that there may exist a threshold or level of intensity at which students' cognitive preference and their uses of metacognitive strategies during learning, may combine by the students to support the later performance. The findings of this study provide practical implications for how instructional designers or teachers can promote student learning, performance, and motivation in e-learning. With regard to goal orientation and need for cognition, e-learning system should provide timely supports that focus on how much students can learn and help them see that making mistakes is part of the learning process. Our exploratory study suggests that further research is needed to examine how individual differences in prior knowledge, goal orientation, and need for cognition affect students' uses of learning strategies and their response/reaction to teaching strategies. The replication of current study with students of other age groups to see if the results hold true is also necessary.

References

- Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, 84, 261–271.
- Ames, C., & Archer, J. (1988). Achievement goals in the classroom students' learning strategies and motivation processes. *Journal of Educational Psychology*, 80, 260-267.
- Church, M. A., Elliot, A. J., & Gable, S. L. (2001). Perceptions of classroom environment, achievement goals, and achievement outcomes. *Journal of Educational Psychology*, 93, 43–54.
- Elliott, J., & Church, M. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality & Social Psychology*, 72(1), 218-232.
- Forsterlee, R., & Ho, R. (1999). An examination of the short form of the need for cognition scale applied in an Australian sample. *Educational and Psychological Measurement*, 59, 471-480.
- Greene, B. A., & Miller, R. B. (1996). Influences on achievement: Goals, perceived ability, and cognitive engagement. *Contemporary Educational Psychology*, 21(2), 181.
- Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology*, 29, 462–482.
- Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research*, 70, 151–179.
- Matuga, J. M. (2009). Self-regulation, goal orientation, and academic achievement of secondary students in online university courses. *Journal of Educational Technology & Society*, 12(3), 4-11.
- Pintrich, P., Conley, A., & Kempler, T. M. (2003). Current issues in achievement goal theory and research. *International Journal of Educational Research*, 39 319-337.
- Pintrich, P., & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications*. Englewood Cliffs, NJ: Prentice-Hall.
- Reeve, J. (1996). *Motivating others*. Boston: Allyn & Bacon.

Expanding the Role of Design to Support CSCL

Daniel Spikol, Center for Learning and Knowledge Technologies, School of Computer Science, Physics, and Mathematics, Linnaeus University, Växjö, Sweden, daniel.spikol@lnu.se

Abstract: This paper argues for the need of different strategies to explore and promote innovative collaborative educational technologies. One strategy can be to expand the role of design in research. By using design processes that guide the realization of products helps to balance the different needs of researchers and practitioners while addressing the challenges of usability, sociability, and learnability. An improved design process is presented that suggests solutions to tackle these challenges for CSCL.

Introduction

Nearly 20 years ago, it was argued that the limitations of computer use for education in the coming decades would likely be less a result of technological limitations than a result of limited human imagination and the constraints of old habits and social structures (Kaput, 1992). These two latest behaviors are still observable in many of today's classrooms and impact the research, design, evaluation, and assessment in the CSCL community (Dillenbourg & Jermann, 2010). Therefore, different strategies are needed to explore and promote innovative educational practices supported by collaborative technologies, and this paper will argue that design can be the catalyst for such a change. The main research question to be raised is as follows: what design approaches can be applied to improve CSCL research in learning environments.

Background

Vatrupu and colleagues (2008) have argued that usability, sociability, and learnability can provide a design framework for CSCL. Dillenbourg and Jermann (2010) position orchestration as the key design implication for making CSCL, “work well” for teachers. These different factors of usability, sociability, learnability, and the notion of “working well” can be classified as design challenges. Additionally, these types of challenges can be considered “ill defined” or “wicked” and they do not map well to rigors of science (Rittel & Webber, 1973). Design-based research for education attempts to solve these challenges by relaying on cycles of prototyping and theory building (DiSessa & Cobb, 2004). The purposes of these iterative cycles are to generate theoretical knowledge and educational innovations (products and services) for the classroom that attempts to bridge research outcomes and the social factors for innovative educational uses. DBR has been shown to be an excellent process for localized research outcomes, but it presents problems for higher-level generalized theories (Cobb et al., 2003). Therefore, a different approach is needed that addresses the design problems of making CSCL “work well” that supports research requirements while keeping in mind the users. Therefore, a revised design approach can be developed to support and guide research and practice can be used to expand local theories and help align CSCL for both science and the user experience.

Inspired by the different design processes and differences between “scientific and design problems” a process can be developed that bridges DBR and interaction design (Ejersbø et al., 2008; Rogers, 2009; Schwartz et al., 2008). Viewing the scientific and design challenges as a single larger one, we can now consider the overall problem as a bridge between educational innovations that supports theory generation and the realization of educational tools (Edelson, 2002; Krippendorff, 2006). Figure 1 illustrates this simplified design process that brings together research and product design. In the figure, the top right side illustrates how scientific problems are identified, hypotheses are formed, data collected, and theories generated. The bottom right represents the creative and engineering design points of view, where the problem can be identified through observation and working with the users, after which designs then can be created and delivered. (This simplified model does not reflect the complexity of either the scientific or professional design process; rather its purpose is for comparison.) For the research community, the outcome is peer-validated and for design, validation is based on the end-user and the market. What this model offers are clear roles for the different stakeholders represented in the design-based research approach for CSCL. In the research space, there are the researchers and the respective organizations (academia, enterprises, funding, etc.). In the use space teachers, learners, and organizations are represented as the users of the system. Each of the different stakeholders has different requirements for outcomes and validation. Shifting the role of the design provides a membrane between theory generation and artifact creation that provides means to address and frame the problems of usability, sociability, and learnability. Additionally, the design space provides a legitimate space to ask does it “work well” for teachers and learners. By considering design as a membrane provides researchers and other stakeholders the tools manage the relationships and help insure both research outcomes and innovative learning artifacts.

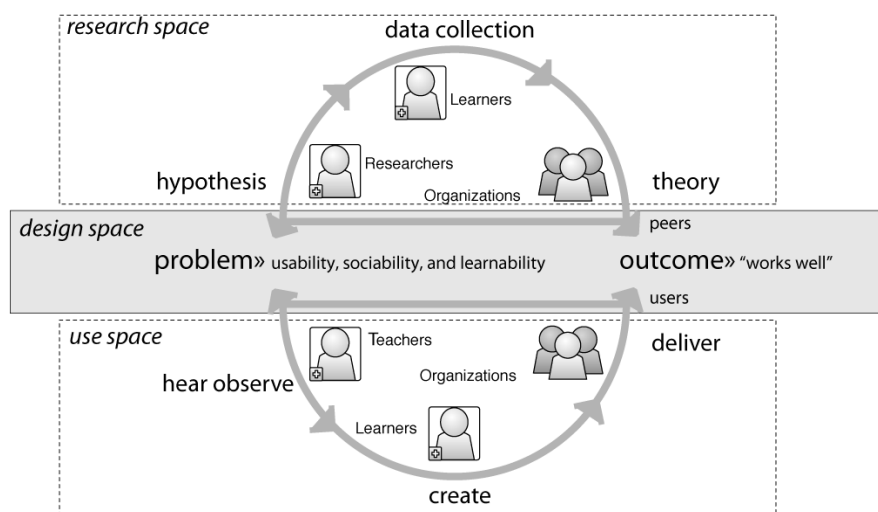


Figure 1. Proposed Role of Design for Supporting CSCL.

Design Process

The design process illustrated intention is to help guide the research and the development and implementation of CSCL. Where the design process differs in its approach, is to help manage the research and product design methods. By adding a research focus to the design process enables a shift from the preoccupation with appearance and surfaces of tangible products to design materials that can make sense to the user of the communities (Krippendorff, 2006). Additionally, design synthesis offers the researcher methodological approaches for going beyond local theories. More empirical work and evidence are required if this expanded role for design is to generate significant results as an approach for CSCL. Dillenbourg and Jermann (2010) have argued that CSCL needs to embrace both individual and social learning while supporting the role of the teachers, and that technology should follow suit, otherwise it will not be adopted into practice. This focus on supporting and empowering teachers and learners is a goal for conducting successful research that requires a different way of framing problems for CSCL.

References

- Cobb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, 32(1), 9-13.
- Dillenbourg, P., & Jermann, P. (2010). Technology for Classroom Orchestration. In M. S. Khine & I. M. Saleh (Eds.), *The New Science of Learning: Computers, Cognition and Collaboration in Education*, Berlin: Springer, 525-552.
- DiSessa, A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *The journal of the learning sciences*, 13(1), 77-103. Lawrence Erlbaum.
- Edelson, D. C. (2002). What We Learn When Design Research: We Engage in Design. *The Journal of the Learning Sciences*, 11(1), 105-121.
- Ejersbø, L. R., Englehardt, R., Frølund, L., Hanghøg, T., Magnussen, R., & Misfeldt, M. (2008). Balancing Product Design and Theoretical Insights. In A. E. Kelly, R. A. Lesch, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Educations: Innovations in Science, Technology, Engineering, and Mathematics Learning and Teaching* (p. 15). New York, New York, USA: Routledge.
- Kaput, J. (1992). Technology and mathematics education. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 515-556). New York, USA: MacMillan Publishing.
- Krippendorff, K. (2006). *The semantic turn: a new foundation for design* (p. 349). CRC Press.
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy sciences*, 4(2), 155-169. Springer.
- Rogers, Y. (2009). The changing face of human-computer interaction in the age of ubiquitous computing. (A. Holzinger & K. Miesenberger, Eds.) *HCI and Usability for e-Inclusion*, 5889, 1-19. Berlin, Springer.
- Schwartz, D., Chang, J., & Martin, L. (2008). Instrumentation and Innovation in Design Experiments: Taking the Turn Towards Efficiency. In A. E. Kelly, R. A. Lesch, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Educations: Innovations in Science, Technology, Engineering, and Mathematics Learning and Teaching* (p. 18). New York, New York, USA: Routledge.
- Vatrapu, R., Suthers, D., & Medina, R. (2008). Usability, Sociability, and Learnability: A CSCL Design Evaluation Framework. *Proceedings of the 16th International Conference on Computers in Education (ICCE 2008)*.

A Supporting System for Pupils' Question-Posing and Peer-Assessment

Zhi-Hong Chen, Graduate Institute of Network Learning Technology, National Central University, Taiwan,
hon@cl.ncu.edu.tw

Euphony F. Y. Yang, Graduate Institute of Network Learning Technology, National Central University, Taiwan,
euphony@cl.ncu.edu.tw

Hsiu-Mei Chang, Graduate Institute of Learning and Instruction, National Central University, Taiwan,
auroraspp@gmail.com

Chih-Mao Chen, Graduate Institute of Network Learning Technology, National Central University, Taiwan,
edgar@cl.ncu.edu.tw

Tak-Wai Chan, Graduate Institute of Network Learning Technology, National Central University, Taiwan,
chan@cl.ncu.edu.tw

Abstract: Although a number of online supporting systems are developed to investigate the effect of question-posing and peer-assessment, most of them target on college and graduate students, rather than pupils. Thus, it is still unclear whether the pedagogies of question-posing and peer-assessment could also be applied to pupils. To this end, a Rabi system is developed to investigate pupils' use of online question-posing and peer-assessment, including the quality of posed questions, and the effect of peer-assessment.

Introduction

Recently, it has attracted more and more researchers' attention to facilitate students to play as an active role in learning activities. Making students pose questions is regarded as a significant element for an effective learning since the constructive process involves a number of cognitive strategies, such as organization, association, elaboration, clarification, and inferring. In addition to individual question-posing, peer-assessment is one of useful approach for collective knowledge, in which students are provided with opportunities to play the role of "assessor" to facilitate the social construction, as well as the cognitive conflict arisen from peers' different opinions (Topping, 1998). Due to these reasons, a number of supporting systems that harness collective knowledge are proposed, such as Question Sharing and Interactive Assessment (QSIA) system (Rafaeli, Barak, Dan-Gur, & Toch, 2004), and Question Posing and Peer Assessment system (Yu, Liu, & Chan, 2004; 2005).

When reviewing these systems, we could find that most studies target college and graduate students as subjects. Little research focuses on the investigation of pupils so that it is unclear whether question-posing could also be applied to pupils. Are pupils capable of posing their questions? What are the qualities of the posed questions? What are their assessing capability and qualities? To answer these questions, there is a need to develop a supporting system that is suitable for pupils so that these research questions could be answered.

Rabi System

Article-reading

In the article-reading phase, teachers prepare materials related to a specific topic so that pupils could login the Rabi system to read the articles. Pupils need to understand these learning materials and generate their questions from the materials. In addition, the article-reading and question-generation phases are inter-related. Pupils could go to the question-generation phase to pose questions, and then back to the article-reading phase to read the article more comprehensively.

Question-posing

The multiple-choice question is the type emphasized in the Rabi system. A multiple-choice question consists of a question stem and four candidate items (i.e., one correct item and three distractive ones). Although the multiple-choice question type is commonly used, there have been few studies providing the scaffolding to guide the students in the question-generation process. With the exception of the 5W1H (where, who, what, why, when, and how) key words provided by the AGQ system (Chang et al., 2005), there has been little effort made to construct the guidance for a question-generation process. Therefore, in this study we propose a six-criterion guidance in the Rabi system. A summary of the six-criterion guidance is listed in Table 1.

Table 1: Main aspects and description of the six-criterion guidance.

Aspects	Criteria	Description
Impact	Relevance	The posed question is relevant to the article
	Significance	The posed question covers key ideas or significant concepts

Expression	Clearness	The statement is terse and easy to understand
	My wordings	The statement is written based on my understanding
Item design	Correctness	The posed question has one and only one correct answer
	Distraction	The posed question provides distractive incorrect answers

Question-answering

The questions generated by the pupils in the previous phase are collected by the Rabi system. The system then distributes these questions so that each pupil receives certain questions generated by peers (see Figure 1). In the question-answering phase, pupils are asked to answer these questions first and then assess them in the peer-assessment phase. The design rationale for the question-answering phase is to make students have better awareness when examining these questions from the perspective of “answerer.”

Peer-assessment

In the peer-assessment phase, pupils are asked to evaluate the assigned questions according to the same six-criterion used in the question-generation phase. The six-criterion guidance helps pupils to assess peer-generated questions. Since pupils apply the same criteria during the question-generation and peer-assessment phases, they are able to compare the opinions as both “generator” and “assessor.” This might help them to judge peers’ products from different perspectives. A 5-point scale is used for scoring each criterion, ranging from strongly disagree (1 point), disagree (2 points), neutral (3 points), agree (4 points), to strongly agree (5 points). In other words, pupils are asked to give their comments to the assigned questions according to the six-criterion guidance by assigning them a ranking of 1 to 5 points.



Figure 1. Snapshots of the Question-posing and Peer-assessment Phases.

Work in Progress

After the Rabi system was developed, an experiment was planning to be conducted to address the research questions. The target participants were fifth-grade elementary school students. The learning material included articles and animations for children about financial management that are provided by Citi Bank. The question type was emphasized on multiple-choice because it is a common type that elementary students are familiar.

References

- Rafaeli, S., Barak, M., Dan-Gur, Y., & Toch, E. (2004). QSIA: a web-based environment for learning, assessing and knowledge sharing in communities, *Computers & Education*, 43(3), 273–289.
- Topping, K. J. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research*, 68, 249-276.
- Yu, F. Y., Liu, Y. H., & Chan, T. W. (2004). A networked question-posing and peer assessment learning system: A cognitive enhancing tool. *Journal of Educational Technology Systems*, 32 (2), 213-228.
- Yu, F. Y., Liu, Y. H., & Chan, T. W. (2005). A web-based learning system for question-posing and peer assessment: Pedagogical design and preliminary evaluation. *Innovations in Education and Teaching International*, 42 (2), 337-348.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financial support no: NSC-99-2631-S-008-001 and NSC-99-2511-S-008-002.

Orchestrating CSCL - More Than a Metaphor?

Ingo Kollar, Ludwig-Maximilians-University of Munich, Martiusstr. 4, 80802 Munich, Germany,
ingo.kollar@psy.lmu.de

Raija Hämäläinen, Finnish Institute for Educational Research, Keskussairaalan tie 2, 40014 University of
Jyväskylä, Finland, raija.hamalainen@ktl.jyu.fi

Michael A. Evans, Department of Learning Sciences and Technologies, Virginia Tech, 300 War Memorial Hall,
Blacksburg, VA, USA, mae@vt.edu

Bram De Wever, Department of Educational Studies, Ghent University, H. Dunantlaan 2, 9000 Gent, Belgium,
bram.dewever@ugent.be

Carlo Perrotta, Futurelab, 45 Great Guildford Street, London, UK, SE1 0ES,
c.perrotta@ioe.ac.uk

Abstract: Orchestrating learning as a metaphor for developing and investigating learning environments has gained traction among CSCL scholars and practitioners. We propose a formalization of the metaphor attempting to assess its usefulness to reconstruct two CSCL scenarios and its power to influence future CSCL theory building, research, and practice. Also, we discuss what role digital technologies can play in orchestrating CSCL.

What Are Components of Orchestras and the Orchestration Process?

In CSCL research (e.g., Dillenbourg, Järvelä & Fischer, 2009), the term “orchestration” has been used to re-emphasize the central role of the teacher, which may be regarded as a reaction towards prior CSCL research that has tried to develop learning environments that would rather replace the teacher than put him/her to the centre. However, a critical discussion on the value of the orchestration metaphor appears to be missing. To determine its usefulness, we first decompose orchestras and the process of orchestration into six components.

The first component of an orchestra is the *conductor* (1), whose function is to interpret a piece of music and manage the orchestra to play well together to finally produce and perform a piece of music. Second, an orchestra consists of *musicians* (2) who play their parts of the score and who may be grouped according to their function for the orchestra (e.g., strings or woodwind). Third, orchestras rely on a *score* (3), which “tells” the conductor and the musicians the kind of music they are aiming to perform. Fourth, an orchestra uses a variety of *instruments and tools* (4), some of which are used by the conductor (e.g., the baton) while others are used by all (e.g., the music stands) or some of the musicians (e.g., the cellos). A fifth component of orchestration is its product, i.e. a *musical piece* (5) to an *audience* (6), which is the sixth component of an orchestra.

Can the Orchestration Metaphor Be Used to Reconstruct Different Learning Scenarios?

In the following we try to apply the orchestration metaphor to reconstruct two CSCL scenarios:

Example 1: Instruction for shared knowledge construction in a higher education setting. The first CSCL scenario was used in a course “Learning and Interaction” offered at a Finnish university. The aim of the course was to enhance student groups' understanding of relations between socio-cultural and socio-cognitive perspectives of collaborative learning. The idea was to structure the student groups' collaborative activities in f2f and virtual settings. The *teacher* (1) very much resembled a conductor of an orchestra: Her role was to manage the course by interpreting and applying conceptions of a national level curriculum of the Subject Studies in Education. Moreover, she set the learning goals, chose external resources, and managed and supported group collaboration, helping students to “play together” in the classroom “ecosystem”. The *students* (2) could be viewed in analogy to the musicians in an orchestra. The aim of the student groups was particularly to combine their knowledge construction processes and play well together. The *lesson plan* (3) was influenced by National Curriculum standards (as a score is influenced/created by a composer), but in the end it was the teacher who designed the specific instance of the plan. This was done on the basis of the Jigsaw approach (Aronson et al., 1978), during which students became experts in one theory and were subsequently grouped together with students who were experts in another theory. Then, their task was to explain the theories to each other. During the course a number of different *instruments and tools* (4) were used. For example, there were two web-based learning environments, one primarily for the realization of the learning phases to be orchestrated by the teacher and participated in by the students, and the other for the groups' knowledge construction. The product of the “orchestra” emphasized *collaborative learning* (5) as culturally organized social interaction and a process of groups' knowledge construction. Like an orchestra, thus, the learning group created a joint product. There is friction in applying the metaphor for the audience level (6). Thinking about the audience, in educational contexts leads to ask “whom are we learning for and how is learning performed?” Thus, in our example, from an individual perspective learning could be “performed” within individualized, written tests. From a group

perspective, the whole classroom can be seen as the audience. We could also argue that learning produces competences that are required and welcome in our society, and then society may be interpreted as audience.

Example 2: Knowledge-building in an informal science learning setting using digital video games. The second CSCL scenario involved a group of Grade 10 students (n=12) who participated in a series of workshops led by four graduate students from a research university to introduce participants to two video games titled *Spore* and *Spore Galactic Adventures (SGA)*. *Spore* grants the user the ability to navigate a simple cell creature through a series of challenges meant to parallel the evolution of a species. *SGA* provides a level builder whereby students generate their own games. Given the informal nature of the arrangement, the teacher played less the role of the *conductor* (1) and more the manager of the orchestra and composer of the score. The actual conductors were the four graduate students who ran the workshops as part of a course assignment. The 12 workshop participants can partially be regarded as resembling the *musicians* (2) in an orchestra, particularly in the earlier stages as they played through the stages of *Spore*. However, once they began building games in *SGA*, they gradually became co-authors of the *score*. The *lesson plan* (3) consisted of biweekly 1.5-hour workshops during the school year. These workshops provided a clear sequence of learning activities (e.g., participants watched instructional videos that demonstrated the capabilities of the software and later created their own creatures and game levels) which thus resembled the score of an orchestra. However, it left room for interpretation on behalf of the students, which stands in some contrast to the idea of a “score”. With respect to *instruments and tools* (4), the used digital technologies were designed in a way that went beyond the familiar role of instruments and tools in an orchestra. In *Spore* and *SGA*, one person can play at a computer, but has access to thousands of *Spore* players via the Internet, cracking up the boundaries of the orchestra to a virtually infinite number of players. The envisioned *product* (5) of the project was to have the learners act as a knowledge building community that contributes to the knowledge on *Spore* and *SGA* already available on the WWW. This goes well along with the notion of orchestras delivering a group product to an audience. Finally, the scenario shows how digital technologies can bring an *audience* (6) into educational processes, since each group created its own evolution adventure and shared it on the Sporepedia website to a virtually infinite number of other players.

Discussion

The two examples show that the extent to which the orchestration metaphor can be used to reconstruct different CSCL scenarios depends on the type of scenario under study. There certainly is friction when one tries to adopt the metaphor, but we think that this friction can be used productively to re-think important issues in educational theory-building, empirical research, and practice. Two exemplary questions are presented to justify this claim:

(1) *How should learning look like and what should be learned in future formal and informal learning?*

In an orchestra, the conductor is the centre. Based on the score, s/he signals the players what to play, when to play, how to play, and with whom to play. It may however be questioned if a teacher should always be “on the podium”, or whether an alternative exists. The discussion about the so-called 21st century skills (Voogt & Knezek, 2008) revealed that besides a systematic knowledge base, students also need to acquire more general skills such as communicative and collaborative competences. For such rather general (social) skills to be acquired, direct instruction may need to be augmented by more participatory instructional approaches (e.g., Scardamalia & Bereiter, 2006), as is the case in the two scenarios we presented.

(2) *What should the role of digital technologies be in future formal and informal learning?* Digital technologies can be interpreted in analogy to instruments used in an orchestra. Some of them are used by the teacher (e.g., a learning management system, see example 1), whereas others are used by the students (e.g., laptops to access Sporepedia, see example 2). Yet, the use of digital technologies can also lead to challenging the orchestration metaphor: Example 2 showed that technologies can make the group of “musicians” much bigger than an orchestra could ever be, since it brings together players from all over the world. An adjacent research question could be how learning is affected by the presence of such a large group of collaborators and spectators, which demonstrates that the orchestration metaphor bears potential to inspire future CSCL research.

References

- Aronson, E., Blaney, N., Stepin, C., Sikes, J., & Snapp, M. (1978). *The jigsaw classroom*. Beverly Hills, CA: Sage Publishing Company.
- Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning: from design to orchestration. In N. Balacheff, S. Ludvigsen, T. de Jong, T., A. Lazonder & S. Barnes (Eds.), *Technology-Enhanced Learning* (pp. 3-19). New York: Springer.
- Scardamalia, M. & Bereiter, C. (2006). Knowledge building: Theory, pedagogy and technology. In K. Sawyer (Ed.), *Cambridge handbook of the Learning Sciences* (pp. 97-118). New York: Cambridge Univ. Press.
- Voogt, J. & Knezek, G. (2008). IT in primary and secondary education: Emerging Issues. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education. Part one* (pp. xxix-xlii). New York: Springer.
- Watts, D. M. (2003). The orchestration of teaching and learning methods in science education. *Canadian Journal for Science Mathematics and Technology*, 3(4), 451-465.

Epistemic Mediation, Chronotope, and Expansive Knowledge Practices

Kai Hakkarainen, Department of Education, Assistentinkatu 5, 20014 University of Turku, Finland
kai.hakkarainen@utu.fi

Giuseppe Ritella, Centre for Research on Activity, Development, and Learning (CRADLE), Institute for Behavioural Sciences, P.O. Box 9, SF-00014 University of Helsinki, giuseppe.ritella@helsinki.fi

Pirita Seitamaa-Hakkarainen, Centre for Research on Activity, Development, and Learning (CRADLE), Department of Teacher Education, P.O. Box 9, SF-00014 University of Helsinki, pirita.seitamaa-hakkarainen@helsinki.fi

Abstract: In this poster we examine the role of epistemic mediation in technology-mediated collaborative learning. We argue that participants in technology-mediated learning deal with amplified, temporally integrated and spatially merged semiotic resources, constituting specific chronotopes. The cultivation of such chronotopes, characterized by the creation of epistemic artifacts that crystallize cognitive processes and re-mediate activity, requires expansive learning efforts that transform the entire activity system. Investigation of such chronotopes seems a promising line of inquiry in CSCL.

In the investigation of technology-mediated learning, it is essential to acknowledge that human beings use various External Memory Fields (EXMF, Donald, 1991), such as paper and pencil, for extensive elaboration of ideas. EXMF provides material agency (Pickering, 1995) for pursuing complex inquiries and participates in the process of externalization and collectivization of cognitive processes (Donald, 1991). One basic aspect of the use of EXMF in learning is epistemic mediation, i.e., a process of deliberate re-mediation of personal and collective activity by the creation of epistemic artifacts, a growing network of which remediate subsequent inquiry. Artifacts, in fact, bear knowledge (Baird, 2004) so that their design may crystallize a whole expert network's knowledge, which can afterwards be taken as a black box (Tuomi, 2002). Artifacts, then, become instruments that mediate subsequent inquiry (Beguin & Rabardel, 2000), becoming part of the invisible background of activities (Engeström, 1987). EXMF and knowledge practices, through epistemic mediation, generate specific spaces of interaction and specific temporal organizations of learning activities analyzable through the concept of chronotope (Bakhtin, 1981). In this poster we will briefly discuss the relations between epistemic mediation in CSCL, knowledge practices and emergent space-time relations.

Pioneering research on epistemic mediation in CSCL has been carried out by Scardamalia and Bereiter (2006). The authors, in their design based experiments, guided students in developing knowledge through the embodiment of their ideas in conceptual artifacts (Bereiter, 2002), having both ideal and thing-like characteristics. The concept of mediation is central also within cultural-historical activity theory (Engeström, 1987), as an aspect of mediated activity: ideas and conceptualizations are seen as psychological tools in materially embodied activities (Vygotsky, 1978). By building on those theories, the first author and his colleagues developed the "knowledge-creation learning" (Paavola et al., 2004), characterized as a object-centered approach to CSCL in which the nature of the material objects worked on mediates and significantly shapes the nature of inquiry.

In our vision, EXMF is part of a dynamic semiotic field that intersect boundaries of mental, virtual, and social spaces of activity (Nonaka & Konno, 1998), which can be considered part of the chronotope of technology-mediated learning (Ligorio & Ritella, 2010). Chronotope is Bakhtin's (1981) concept originally devised for understanding how literate genres of novels define specific ways of interconnecting spatial and temporal relations (Tuomi, 2002). In educational context, Brown and Renshaw (2006, p. 249) used chronotope in order to show how pupils participation in classroom activities is linked to the way they discursively shape "the space-time context of the classroom". For our purposes, we define the chronotope in ICT-mediated learning as the emergent configuration of temporal and spatial relations in learning practices as they are impacted by ICT. In fact, the entire flow of activity, in terms of temporally organized sequence of actions, is impacted by the use of different EXMF. Moreover, interacting with EXMF provide semiotic spaces organized in multiple ways. Suffice it to think of the difference between the organization of books in a library and in Google books. Following Bakhtin, we consider spatial and temporal processes as fused: chronotope invoke a whole, so that 'reciprocal impact' of space and time is an approximation in the understanding of the process.

Chronotope is useful in technology-mediated learning because ICT break many traditional spatial and temporal boundaries of human activity. Indeed, educational settings are to be considered what Foucault (1967) called a "heterotopia", i. e. a place in which multiple types of physical and symbolic space coexist and alternate. Digital epistemic artifacts even transform and enrich the heterotopia of learning, while ICT permit to create easily shareable and workable epistemic artifacts which transform distributed problem space and provide

anticipatory guidance for future inquiry. So, such learning is a multimodal and laminated (i.e., spatiotemporally layered) activity (Prior, 1998) in which social practices related to epistemic mediation are crucial.

In Ligorio & Ritella (2010), chronotope has been characterized by the use of the musical metaphor for the analysis of the tempo of the activity. Three chronotopes, related to different rhythms emergent in collaborative interaction, have been identified (Ligorio & Ritella, 2010): 1) adagio, characterized by a slow flow of action 2) andante, characterized by an acceleration of the flow and 3) allegretto, in which the configuration of participation allow a fluid and dynamic course of actions. Some features such as “the depth and the size of the space of interaction” and “how participants move around the computer and within the digital space” play an important role in the emergence of specific chronotopes. Building on this work, we characterize the chronotopes of technology-mediated learning as follow: 1) they are marked by changes in the tempo of the activity and occasional intensification of collaboration, and they permit to explain variations in the pace and in the emerging organization of collaborative processes (Ligorio & Ritella, 2010); 2) they involve the use of collaborative technology; 3) epistemic mediation plays a crucial role; 4) they are characterized by multimodality, heterogeneity and multi-modality; 5) they are locally improvised, but also mediated by socio-historically developed genres, technology-based instruments, and educational practices.

Technology enhances learning through transformed social practices (Hakkarainen, 2009), as successful cultures of CSCL appear to be also expansive-learning communities (Engeström, 1987) which problematize practices, envision changes and consolidate novel practices. Accordingly, the emergence of a new chronotope implies both the transformation of the arrangement of the space and of the practices that occur within that space. That new pattern generates also a new time perspective and impacts the tempo of the activity, making the new chronotope emerge. The development of chronotopes of knowledge creation is, then, a collaboratively emergent process (Sawyer, 2005), seldom analyzed by investigators who either pursue one-shot experiments or describe mature inquiry cultures. Detailed multi-level data on transformative activities are needed to account for such dynamic emergent processes. In fact, evolution of practices is elicited by selectively consolidating ephemeral as well as stable aspects of CSCL. Through sustained collaborative improvisation, ideas, artifacts, methods and practices that do not belong to individuals, emerge from self-organized collaborative processes (Fleck, 1979).

Concluding, epistemic mediation, chronotope and knowledge practices appear to have three interconnected aspects: 1) In order to transform technological artifacts to instruments of inquiry, expansive development of knowledge practices is needed. 2) When adequate, practices guide participants’ activities toward epistemic mediation. 3) The emergence of a new chronotope elicits collaborative creation of knowledge. The notion of chronotope appears useful because it assists in understanding how dynamic semiotic spaces are associated with social practices; the challenge is to create methods that allow investigating such processes.

References

- Baird, D. (2004). *Thing knowledge*. Berkeley, CA: University of California Press.
- Bakhtin, M. (1981). *The dialogic Imagination. Four essays by M. M. Bakhtin*. Austin: University of Texas Press
- Bazerman, C. (1988). *Shaping written knowledge*. Madison: University of Wisconsin Press.
- Béguin, P., & Rabardel, P. (2000) Designing for instrument-mediated activity. *SJIS*, 12, 173–190.
- Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Erlbaum.
- Brown, R. & Renshaw, P. (2006). Positioning Students as Actors and Authors: A Chronotopic Analysis of Collaborative Learning Activities. *Mind, Culture, and Activity*, 13(3), 244-256.
- Donald, M. (1991). *Origins of the modern mind*. Cambridge, MA: Harvard University Press.
- Engeström, Y. (1987). *Learning by expanding*. Helsinki: Orienta-Konsultit.
- Fleck, L. (1979). *Genesis and Development of a Scientific Fact*. University of Chicago Press.
- Foucault, M. (1967). Of other spaces, heterotopias. <http://foucault.info/documents/heteroTopia/foucault.heteroTopia.en.html>
- Hakkarainen, K. (2009). A knowledge-practice perspective on technology-mediated learning. *ijCSCL*, 4, 213-231.
- Ligorio M. B., Ritella G., (2010). Chronotopes and heterotopias as conceptual tools to understand the development of a computer supported collaborative professional task. *ijCSCL*, 5, 433-452
- Nonaka, I., Konno, N. (1998) The concept of BA. *California Management Review*, 40, 40-54.
- Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Modeling innovative knowledge communities: A knowledge-creation approach to learning. *Review of Educational Research*, 74, 557-576.
- Pickering, A. (1995) *The mangle of practice*. Chicago: The University of Chicago Press.
- Prior, P. A. (1998). *Writing/disciplinarity*. Mahwah, NJ: LEA.
- Sawyer, R. K. (2005). *Emergence: Societies as complex systems*. Cambridge, MA: Cambridge University Press.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building. In K. Sawyer (Ed.) *The Cambridge handbook of the learning sciences* (pp. 97–115). Cambridge, MA: Cambridge University Press.
- Tuomi, I. (2002). *Networks of innovation*. Oxford: Oxford University Press.
- Vygotski, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Upon the Role of the Teacher in the Informal Learning Setting of an Intercultural Computer Club

Anne Weibert, Birgit Sander, Kai Schubert, University of Siegen, Hölderlinstr. 3, 57068 Siegen, Germany
 Email: Anne.Weibert@uni-siegen.de, Birgit.Sander@uni-siegen.de, Kai.Schubert@uni-siegen.de

Abstract: This poster aims to evaluate the significance of a teacher's doing in the informal learning setting of an after-school activity. We discuss and analyze this, using the example of intercultural computer clubs "come_IN" in Germany. Located in (primary) schools in socially and culturally diverse neighborhoods, these clubs decidedly aim at being everything else but school: offering the chance to get acquainted with modern technology and software.

Introduction

As an after-school activity, the intercultural computer clubs "come_IN" serve to establish and strengthen social relationships in the intercultural neighborhoods by enabling and supporting collaborative practices among the young and adult members of the neighborhoods' mainstream and migrant societal groups. "Come_IN" clubs are located in schools offering the chance to get acquainted with modern technology and software, yet not following a pre-set schedule in doing so. They are putting children and adults in equal positions as learners; having tutors and a teacher offering guidance instead of providing directions that are to be followed. Appropriation of computer technology in "come_IN" results from constant negotiation among its young and adult participants – tutors and teacher amidst them (Veith et al., 2008). We see: unlike the traditional classroom-situation, here the teacher does not stand out. Seeking out the significance of a teacher's doing in this informal learning setting is the aim of this poster. For the evaluation of the role of the teacher in this setting, we conducted a series of semi-structured interviews with teachers from the various clubs.

Related Work and Method of Research

Established in Germany as an advancement of the US computer clubhouses (see e.g. Kafai et al., 2009), referring to issues of intercultural and intergenerational learning, the "come_IN" computer club concept draws on different fields of research. The concept of "come_IN" draws on principles of constructionist thinking and situated learning (e.g. Chapman 2004). The research project is guided by principles of participatory action research (Kemmis & McTaggart, 1988).

Four teachers from the clubs in Bonn and Dortmund were interviewed in the study. All interviewees have club experience of one year. Questions for the interviews have been derived from the "come_IN" concept and the contribution it aims to achieve. Aiming at (a) socio-structural matters, asking for the motivation to participate, IT knowledge and experience, significance of the club in school, tasks and activities in the club, perception of the own role, and (b) aspects of culture, asking for cultural/migration backgrounds and their significance in the club, the community experience, projects that were perceived as either success or failure. Having completed all data collection, we transcribed and coded the interviews, informed by (Lofland & Lofland, 1995; Strauss & Corbin, 2004).

Teacher's Activities during Club Sessions

It lies within the nature of the "come_IN" concept to see all participants in a relatively equal position: decisions upon activities and project work are being conjointly made; children as well as adults can find themselves in the position of both learner and expert; the position of teachers and tutors does not stand out – they fulfill guiding and helping tasks when needed, and other than that subordinate to the respective project work.

The activities of the teacher in "come_IN" can also be seen in relation to the activities of children, adults and tutors: the teacher provides help for children and adults when needed and offers guidance for the development of new ideas. Tutors provide technical help for children, adults and teachers when needed. They also offer guidance for the development of new ideas when needed. Children play, explore, try out, draw and paint, write, take pictures or search the Internet. Their parents and other adults watch, accompany or help the children. They write, take pictures, learn image and film editing or search the Internet.

Discussion of Interview Results

The interviewee's responses point to the blurred line between learner and expert: in the club, teachers found themselves in a situation, where they would be (a) an expert, providing guidance in the development and realization of project ideas, and (b) learners themselves, with regard to the appropriation and use of modern media and computer technology. The teacher does not stand out in intercultural computer clubs "come_IN" – yet, his role is central to a successful implementation and development of this informal learning setting. In the

analysis of the teacher's interviews, six aspects can be identified as central to the role of the teacher in this context.

(1) The teacher as a go-between: Decidedly aiming at being something other than school, the school still influences the structure and atmosphere of intercultural computer clubs "come_IN". Being "at home in both worlds", the teacher often finds him- or herself in the role of a go-between: in casual, rather informal talk with parent participants in the club, enabling peaks of children's general performance in school; in his activities in the computer club being present to the children as something other than the traditional teacher in class. The club being a voluntary after-school activity, teachers would concentrate on the voluntariness as a chance to reach out to the parents on the one hand, and to offer the chance to delve into a topic to the children – a chance that regular lessons frequently do not bring about.

(2) The teacher as a learner: It lays within the "come_IN" concept to blurry the lines dividing experts and learners. In the interviews, teachers recognized the project-related approach to modern media and computer technology as a chance, especially for the children to gain in technological fluency.

(3) The teacher as an attachment figure: One might think that a teacher would not be too central in this kind of setting. A good deal of the club's social structure does depend on the teacher as attachment figure – as someone, who is good company.

(4) The teacher as company: The evaluation of the interviews points to the teacher as a main instance of support for the children in an intercultural computer club "come_IN." Especially to younger children, a familiar teacher and his backing is a needed point of reference. This role is even more comfortable for the teacher: In the computer club, he finds himself in a position, where he can be good company and likewise concentrate on social matters and the development of knowledge and skills.

(5) The teacher as a motivating figure: With intergenerational learning being a central aspect of project work in "come_IN", teachers in the club often find themselves in the position of a mediator between children and parents – a motivating figure for both, children and parent participants in the club. Being closely connected to the children's experience realm in the school's context, teachers in the clubs are in a position where they can introduce parents to a part of their children's world they formerly were not all too familiar with. The teacher as a role model encourages parents to actively engage in the club's project work. He is a motivator for the parents to regularly come and join their kids in the clubs.

(6) The teacher as an expert (transferring knowledge): All interviews show: Rather goal orientated, teachers focus on a project's outcome. What do children learn? What's the concrete result of club project? With this, teachers closely relate to the classical understanding of their role as an expert, transferring knowledge to the learning ones.

Conclusion

We see: the role of the teacher is central to a successful implementation and development of an after-school activity like intercultural computer clubs "come_IN". We see the teacher in this context in a role that goes beyond his traditional position in the school context. Not only do teachers find themselves in the position of being a "key to people", serving as a mediator between children and adult interests. They also mediate among in- and outside-of-school contexts. Teachers themselves described flexibility to be the central prerequisite to meet these characteristics. It is a kind of flexibility, where the lines dividing learners and experts are blurred. Learning in this context is decidedly local, relating to projects from the participants "world" – and the teacher being actively engaged in their realization. Voluntary after-school activity like "come_IN" has to be wanted to make it work.

References

- Chapman, R. (2004). Pearls of Wisdom: Social Capital Building in Informal Learning Environments. In: M. Huysman & V. Wulf (eds.) *Social Capital and Information Technology*. Cambridge: MIT Press, pp. 301-331.
- Kafai, Y. B., Peppler, K. A., Chapman, R. N. (eds.) (2009). *The Computer Clubhouse. Constructionism and Creativity in Youth Communities*. New York: Teachers College Press.
- Kemmis, S., McTaggart, R. (1988). *The action research planner*. Victoria, Australia: Deakin University Press.
- Lofland, J., Lofland, L.H. (1995). *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis*. Belmont, CA: Wadsworth Publishing.
- Strauss, A. L., Corbin, J. (2004). Open Coding. In: Seale, C., *Social Research Methods: A Reader*. New York: Routledge, pp. 303-306.
- Veith, M., Schubert, K., Wulf V. (2008). Fostering Communities in Urban Multi-cultural Neighbourhoods: Some Methodological Reflections. In: Foth, M. (ed.). *Urban Informatics: Community Integration and Implementation*. Hershey, PA: IGI Global, pp. 115-130.

Exploring New Directions in Teachers' Professional Development: Monitoring Teachers' Fidelity of Implementation of (Argumentative) Dialogue

Reuma De-Groot, The Hebrew University of Jerusalem, Jerusalem, Israel - msruma@mscc.huji.ac.il

Abstract: Studies of teachers' fidelity of implementation focus mainly on implementation of well-designed curricular units. Recent work stresses the need to address also teachers' change as a means to achieve better results. After a year-long training in learning-oriented argumentation, teachers barely used it despite their access to dedicated technology. Findings reveal the need to promote discussion and reflection among teachers in the training course to make them more favorable to use argumentation in the classroom.

Introduction

Studies of teachers' fidelity of implementation focus mainly on implementation of well-designed curricular units and specific instructions for teachers (e.g., Penuel 2004, O'Donnel, 2008). Although teachers' fidelity of implementation is linked to teachers' capacity to become learners while training, and teachers tend to develop new pedagogies in complex situations (Edwards, 2001; Edwards et al., 2002), studies that focus on the changes undergone by the teachers in this process are scarce (O'Donnel, 2008). Recent studies in teachers' pedagogical change in the knowledge era point to the need of teachers and students to assume new roles in the classroom (Edwards, 2004). The identification and assessment of this change depends also on the extent to which teachers' professional development addressed their teaching practices in particular (Ball & Cohen, 1999) and teaching practices in general (Grossman et al., 2008).

In the present poster I will describe how five teachers – who participated in a year-long training for implementing argumentative dialogue using the Argonaut system (<http://www.argonaut.org>, De Groot et al., 2007) - used argumentative dialogue with their students in the classroom. The design of argumentative dialogue activities with the use of the Argonaut system was based on the following pedagogical findings and assumptions:

1. The development of critical thinking skills through active engagement in critical and argumentative discourse is an increasingly important objective in education.
2. Argumentative or other form of critical discourse do not occur simply by putting a group of students together, and there is a need to mediate and moderate such discourse to attain the expected results.
3. Using special prompts by teachers in moderating face-to-face classroom discussions through exploratory talk proved to be effective (Mercer, 1995)
4. Using different scripts to manipulate the group work with argumentation- and problem-based learning may facilitate collective peer argumentation. (Weinberger, Ertl, Fischer, & Mandl, 2005; Weinberger, Stegmann, & Fischer, 2005)

The Training Model

Ten teachers participated in a one-year training at the Ziv School in Jerusalem, dealing with the implementation of technology and argumentative dialogue in their current curriculum (De-Groot, 2008, Eizenman and De-Groot, 2008 and De-Groot, in press). During the training the teachers designed teaching units that focused on fostering critical discourse and argumentation using the Digalo (1) tool in their teaching domain. These teaching units were then taught by the teachers to their students (aged 15-16) in their regular classrooms. The training team, consisting of an experienced trainer, a researcher and a coordinator, accompanied the teachers in their classrooms, supporting and identifying critical pedagogical instances for further discussion in the training course. After carrying out at least one session with the Digalo tool in the classroom, we introduced the Argonaut tool to five teachers of the original group in order to enable them to moderate synchronous e-discussions with Digalo (2-5 different discussions simultaneously).

Data Collection

Teachers' face-to-face discussions were videotaped, and their teaching units, as well as written and oral presentations of these units, were content-analyzed to trace critical thinking and argumentative discourse. Teachers' work through the "Moderator's Interface" (the "MI") in Argonaut was videotaped as well, and the teachers were interviewed about their experience.

Findings and Discussion

Preliminary data show that teachers used the Argonaut tool for moderating the Digalo discussions for different purposes than those originally set by the designers and discussed during the training. In fact, teachers used the Argonaut tool as an advanced communication means with their students and as an aid to facilitate their control over their students' work. The fact that the tool actually promotes critical thinking and argumentative dialogue within the group work was barely paid attention by the teachers. We assume that they did not sufficiently value their students' argumentative discourse as a source for learning, apparently because they still felt responsible for their students' work – both on the social (students' participation) and the domain knowledge levels. During the interviews, teachers expressed their pedagogical beliefs regarding their roles as teachers within the learning processes of their students. Our preliminary insights point to a low level of teachers' fidelity of implementation of argumentative dialogue with their students. These findings illustrate the need to monitor and enhance teachers' pedagogical performance during the training as well as to proactively initiate individual and group reflections on the execution of pedagogical design in classroom teaching. In the poster I will identify and highlight the importance of these needs and give some suggestions on possible ways to broaden the use of argumentative dialogue with the support of the Argonaut system in teachers' real work in the classroom.

Endnotes

- (1) The Digalo tool enables the participants in a synchronous written discussion (e.g., of 4 or 5 students) to jointly create a discussion map. Digalo was developed in the DUNES European project (FP5) - <http://www.dunes.gr/>, being later upgraded and integrated in other environments, like the Argonaut system, downloadable from <http://argonaut.collide.info/>.

References

- Ball, D. L. & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes and L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3-32). San Francisco: Jossey Bass.
- Carol L O'Donnell (2008) Defining, Conceptualizing, and Measuring Fidelity of Implementation and Its Relationships and outcomes in K-12 curriculum intervention research. In *Review of Educational Research Mar.*, pp. 33-78 Research Library Core.
- De-Groot, R. (to appear 2010) Teachers use the Argonaut tool To appear in N. Pinkwart, & B. M. McLaren (Eds.), *Educational Technologies for Teaching Argumentation Skills*, Bentham Science Publishers
- De Groot, R., Haim, Y., Riskin, L. and Eisenmann, T. (2008). The Teacher and the Student in an Online Learning Environment: A Model for Professional Development Training. In: Y. Eshet-Alkalai, A. Caspi, & N. Geri (Eds), *Proceedings of the 2008 Chais Conference on Instructional Technologies Research: Learning in the technological era*. Raanana: Open University Press.
- De Groot, R., Drachman, R., Hever, R., Schwartz, B., Hoppe, U., Harrer, A., De Laat, M., Wegerif, R., McLaren, B. M., & Baurens, B. (2007). Computer Supported Moderation of E-Discussions: the ARGUNAUT Approach. In the Proceedings of the Conference on Computer-Supported Collaborative Learning (CSCL).
- Edwards, A. (2001). Researching Pedagogy: a sociocultural agenda. *Pedagogy, Culture and Soc.*, 9(2), 161-186.
- Edwards, A. (2002). Developing Understandings of Agency and Disposition in Sociocultural Accounts of Learning to Teach. Paper presented at the AERA Annual Conference, New Orleans.
- Edwards, A. & D'arcy, C. (2004). Relational agency and disposition in sociocultural accounts of learning to teach. *Educational Review*, 56(2), 147- 155.
- Eisenmann T, Schwarz, B. De-Groot, R. (2008) Integration of technological tools into teachers daily work, presented in ECER, Goteborg, Sweden, 8-12 September, 2008.
- Grossman, P, Compton, C., Igra, D., Ronfeldt, M., Shanahan, E. & Williamson, P. (2008). Teaching Practice: A Cross-Professional Perspective. Manuscript submitted for publication, Stanford University.
- Mercer, N. (1995). The guided construction of knowledge. Talk amongst teachers and learners. Clevedon, UK: Multilingual matters.
- Penuel W.R, Means, B (2004) Implementation variation and fidelity in an inquiry science program: Analysis of GLOBE data - *Journal of Research in Science Teaching* p.1-24 - interscience.wiley.com .
- Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer-supported collaborative learning. *Instructional Science*, 33(1), 1-30.
- Weinberger, A., Stegmann, K., & Fischer, F. (2005). Computer-supported collaborative learning in higher education: Scripts for argumentative knowledge construction in distributed groups. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.), *Computer Supported Collaborative Learning 2005: The Next 10 Years!* (pp. 717-726). Mahwah, NJ: Lawrence Erlbaum Associates.

Linking Genotypic and Phenotypic Ideas of Evolution through Collaborative Critique-focused Concept Mapping

Beat A. Schwendimann, University of California, Berkeley, beat.schwendimann@gmail.com

Abstract: Students' alternative ideas about evolution are often poorly integrated. One cause could be the difficulty in linking observable (phenotype) and unobservable (genotype) concepts. This study investigates how two different treatments (generation and critique) of a novel form of computer-supported concept map can support students' collaborative learning from an inquiry-based evolution curriculum. Findings indicate that students in both treatment groups gained significantly in connecting genotype and phenotype ideas. Results suggest that critiquing concept maps can be used as a more time-efficient alternative to generating concept maps.

Introduction

The theory of evolution is a unifying theory of modern biology, and notoriously difficult for students to understand (diSessa, 2008). Many people continue to use 'need' as a central element in their reasoning about evolutionary change, even after years of instruction, such as the example "Humans became lactose tolerant because they needed this trait to survive" (Alters & Nelson, 2002; Bishop & Anderson, 1990; Shtulman, 2006; Southerland, Abrams, Cummins, & Anzelmo, 2001). This study poses the hypothesis that the continued use of the concept 'need' to explain evolutionary change is caused by a disconnection between phenotype-level and genotype-level concepts. The distinction between phenotype and genotype level is fundamental to the understanding of heredity and development of organisms (Mayr, 1988). This study investigates how student dyads learn from an inquiry-based evolution curriculum by either co-constructing concept maps or co-critiquing concept maps that distinguish genotype and phenotype-level concepts. Students generated their own criteria to critique the maps and negotiated with their partner how to revise the map.

Research Questions

This study compares learning from two generative collaborative learning tools: Learners in the *generation* group create concept maps from a given list of concepts and learners in the *critique* group revise concept maps with deliberate errors. This study explores the question how do *generation* or *critique* activities using domain-specific concept maps support students' integration of evolution ideas within and across the genotype and phenotype domain?

Theoretical Framework

This study uses the knowledge integration framework (Linn, Davis, & Eylon, 2004) as its operational framework to build and evaluate a curriculum that focuses on the connection between genotype and phenotype ideas. This study proposes a novel form of biology-specific structured concept map that is divided into a genotype and a phenotype area. This spatial division elicits cross-connections between levels.

Methods

Curriculum Design

A weeklong curriculum module, Gene Pool Explorer, was developed for this study. The Gene Pool Explorer module uses human lactose intolerance as a case study for human evolution. The module was implemented using the web-based inquiry science environment (WISE) (Linn & Hsi, 2000). The WISE module features several animations and a series of guided inquiry activities using the dynamic population genetics visualization "Allele A1" (Herron, 2003). The java-based concept-mapping tool Cmap (IHMC) was used in this study.

Participants

The project was implemented in four high school classes with an ethnically and SES diverse student population of 9th and 10th graders (n=96). Student dyads were randomly assigned to one of the two experimental conditions (generation or critique).

Data Sources

This study uses a pre/posttest design to measure student's prior knowledge and illustrate their learning gains. The tests consist of identical multiple-choice items, short essay items, a concept map critique task, and a

concept map generation task. Additionally, embedded assessment items, field notes, and teacher interview data was collected.

Analysis

I) Pretest and posttest items were scored according to a five-level knowledge integration rubric (Linn, Lee, Tinker, Husic, & Chiu, 2006). Higher knowledge integration scores indicate more complex normative links among different ideas relevant to the genetic basis of evolution. Multiple regression analysis was used to determine the explanatory value of the variables treatment, teacher, class, gender, pretest score, and concept map variables.

II) Concept map analysis: A) Propositional level: A five-level knowledge integration rubric for concept map propositions (Schwendimann, 2007) was used to determine changes in link quality. B) Network analysis was used to identify changes in centrality (outgoing connections) and prestige (incoming connections) of expert-selected indicator concepts "mutation" and "natural selection".

Results

Results indicate that students in both treatment groups gained significantly from pretest to posttest. $t(96) = -5.45$, $p=0.00$. Students in both treatment groups (critique and generation) used the alternative idea "need" significantly fewer times in the posttest than in the pretest ($t(96) = -2.67$, $p<0.01$), with a trend towards the critique group outperforming the generation group. Network analysis indicates that students in both groups created significantly more links to the concept "mutation" in the posttest concept map than in the pretest map ($t(94) = -5.39$, $p=0.00$), with a trend towards the critique group showing larger gains. Students in both treatment groups created significantly more cross-connections between phenotype and genotype concepts in the posttest map, $t(94) = -8.08$, $p=0.00$. Results indicate that the embedded concept map critique activities took significantly less time than the concept map generation activities ($t(27)=2.72$, $p=0.01$).

Discussion

Results suggest that the curriculum Gene Pool Explorer helped students integrate their genotype and phenotype level concepts. Students in both treatment groups made more coherent links to the concept "mutation" in the posttest map, which coincided with fewer uses of the alternative idea "need" in posttest explanations. Findings suggest that collaborative critique activities of biology-specific concept maps can be a beneficial alternative to generating concept maps. This study suggests that critiquing concept maps can be used as a time-effective alternative to generating concept maps.

Significance of Work

The findings from this study are valuable for the design of effective collaborative learning environments to support more integrated understanding of evolutionary biology.

References

- Alters, B. J., & Nelson, C. E. (2002). Perspective: Teaching evolution in higher education. *Evolution*, 56(10), 1891-1901.
- Bishop, B. A., & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution. *Journal of Research in Science Teaching*, 27(5), 415-427.
- diSessa, A. A. (2008). A bird's eye view of the "pieces" vs. "Coherence" controversy. In S. Vosniadou (Ed.), *International handbook of research on conceptual change*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Herron, J. C. (2003). *Allele A1 population genetics software* [Audiovisual Material].
- Linn, M. C., & Hsi, S. (2000). *Computers, teachers, peers: Science learning partners*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Linn, M. C., Davis, E. A., & Eylon, B. -S. (2004). The scaffolded knowledge integration framework for instruction. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet environments for science education*. (pp. 47-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Linn, M. C., Lee, H. -S., Tinker, R., Husic, F., & Chiu, J. L. (2006). Teaching and assessing knowledge integration in science. *Science*, 313(5790), 1049-1050.
- Mayr, E. (1988). *Toward a new philosophy of biology*. Cambridge, MA: Harvard University Press.
- Schwendimann, B. (2007). Integrating interactive genetics visualizations into high school biology. *Annual meeting of american educational research association (AERA)*.
- Shtulman, A. (2006). Qualitative differences between naive and scientific theories of evolution. *Cognitive Psychol*, 52(2), 170-194. doi:10.1016/j.cogpsych.2005.10.001
- Southerland, S. A., Abrams, E., Cummins, C. L., & Anzelmo, J. (2001). Understanding students' explanations of biological phenomena: Conceptual frameworks or p-prims? *Science Education*, 85(4), 328-348.

Distinguishing Evolution Ideas through Two Different Forms of Collaborative Critique-Focused Concept Mapping Activities

Beat A. Schwendimann, University of California, Berkeley, beat.schwendimann@gmail.com

Abstract: Understanding evolution requires distinguishing ideas on observable (organism) and unobservable (genetic) levels. This study explored two different treatment groups using a novel form of concept map that elicits connections between levels: Student dyads compared their concept maps against an expert-generated or a peer-generated concept map. Both groups made significant gains connecting evolution ideas across levels, but used different criteria: The expert-map group focused mostly on surface criteria while the peer-review group used more specific criteria.

Objectives

Evolution ideas are found on multiple connected levels, for example genetic, cell, and organism. This study aims to connect evolution ideas through dynamic computer-based inquiry activities and collaborative concept maps activities. Generating a coherent concept map often requires a subsequent revision step (Schwendimann, 2007). Revision activities require students to generate criteria that allow comparing against a benchmark. This study compares two different collaborative biology-specific concept map critique activities: Expert-generated benchmark maps vs. peer-generated benchmark maps.

Theoretical Framework

This study uses the knowledge integration framework (Linn, Davis, & Eylon, 2004) as its operational framework to build and evaluate a curriculum that focuses on the connections between ideas on a genetic, cellular, and organism level. This study proposes a novel form of non-hierarchical biology-specific concept map that is divided into three field-specific areas (genetic, cellular, and organism/population).

Research Questions

This study investigated two research questions: 1) How does collaborative comparison and critique of biology-specific concept maps against expert or peer benchmark maps impact learning about evolution? 2) What criteria do students collaboratively generate for comparing individual concept maps against expert and peer work?

Methods

The weeklong WISE module *Space Colony – Genetic diversity and survival* was implemented by two teachers, each with two 9th and 10th grade classes in the same public high school (n=81). One class from each teacher was randomly selected for either treatment (expert map or peer map comparison). During the project, students worked collaboratively in randomly assigned dyads. *Space Colony* included the dynamic population genetics visualization *EvolutionLab* (biologyinmotion.com, n.d.) that allowed students to investigate the effects of mutation rate and natural selection on genetic diversity. Following the *EvolutionLab* activity, students worked in dyads creating concept maps from six given ideas. First, students placed each idea in the corresponding area (genetic, cellular, or organism/population), and connected ideas with labeled arrows. Following the concept map construction, the students compared their concept map against a benchmark map – either an expert-constructed map or the map of an anonymous peer. Each dyad decided upon and negotiated its own criteria.

Data Sources

Pretest and posttests consisted of nine multiple choice and explanation items that assessed changes in students' connections between genetic and evolution concepts. Tests were coded using a five-scale knowledge integration rubric (Linn, Lee, Tinker, Husic, & Chiu, 2006). Concept maps propositions were coded on a five-scale knowledge integration rubric for concept maps (Schwendimann, 2008). The rubric distinguishes between link label, link direction, concept placement, and cross-links.

Results

Research question 1: Results suggest that the combination of critique-focused concept mapping and a dynamic visualization helped students in both treatment groups generating novel connections between ideas in different levels. Both treatment groups showed equal gains from pretest to posttest, $t(80) = 4.151$, $p < 0.001$, Effect size (Cohen's d) = 0.52 (SD pretest = 2.78, SD posttest = 3.17). However, regression analysis indicates that the peer map group created more cross-links after the revision than the expert map group (while keeping the coefficient for the initial number of cross-links constant), $R^2 = 0.9917$, $F(2, 78) = 4680.91$, $p = 0.025$

Research question 2: Results suggest that both treatment groups significantly improved their concept maps through the critique activity, $t(80) = 4.13, p < 0.001$. Students in both treatment groups used a broad variety of criteria to review and compare different aspects of concept maps. However, the two treatment groups differed in their use of different criteria: Students in the expert-map group used mostly concept placement criteria (31%). Seven percent critiqued a missing link label and 6% suggested changing an existing link label. Students in the peer-map group used a larger variety of criteria. Sixteen percent also criticized the misplacement of a concept and 11% pointed out a missing label, but another 9% suggested adding a missing link, and 2% analyzed the direction of an arrow.

Discussion

Findings suggest that the WISE module '*Space colony*' helped students in both treatment groups to integrate their evolution ideas within and across levels. The visual structure of biology-specific concepts maps can support collaborative critique activities. Many students in the expert-comparison group seem to have interpreted the expert map as the one "correct" solution. Results indicate that students in the peer critique group used a wider variety of criteria, especially criteria that require conceptual reflection (label revision, arrow direction, and adding a link). Critiquing peer work sets students in a position of equal authority to critique each other's work while valuing their own ideas. Peer work is often using familiar vocabulary and can be more accessible to students than expert work.

Significance and Implications

Both critique activities can support reflection through criteria generation and revision. Critical reflection can support students' self-monitoring of their learning progress. When designing collaborative critique activities, expert and/or peer work critique could be used to support different forms of critique toward a more coherent understanding of biology ideas.

References

- biologyinmotion.com. (2009). *Evolutionlab*.
- Linn, M. C., Davis, E. A., & Eylon, B. -S. (2004). The scaffolded knowledge integration framework for instruction. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet environments for science education*. (pp. 47-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Linn, M. C., Lee, H. -S., Tinker, R., Husic, F., & Chiu, J. L. (2006). Teaching and assessing knowledge integration in science. *Science*, *313*(5790), 1049-1050.
- Schwendimann, B. (2007). Integrating interactive genetics visualizations into high school biology. *Annual meeting of american educational research association (AERA)*.
- Schwendimann, B. (2008). Scaffolding an interactive dynamic model to promote coherent connections in high school biology. *Annual meeting of the american education research association (AERA)*. New York, NY.

Single- and Mixed-Gender Pairs' Help-Seeking and Domain-Knowledge Gains in Collaborative Inquiry-Learning Classroom

Kati Mäkitalo-Siegl, University of Jyväskylä, P.O. Box 45, 40041 University of Jyväskylä, Finland,
kati.makitalo-siegl@jyu.fi

Frank Fischer, Carmen Kohnle, University of Munich, Leopoldstr. 13, 80802 Munich, Germany
Email: frank.fischer@lmu.de, kohnlecm@gmx.de

Abstract: This study explored single- vs. mixed-gender pairs' ($N = 35$ dyads) help-seeking processes and domain-knowledge gains in secondary science education. The results of the quantitative analyses show that the gender composition of the group had no substantial effect on the pattern of student help-seeking processes and domain-knowledge gains in the classroom. To explore this further, qualitative analysis of single- and mixed-gender pairs and their ways of working will be conducted.

Introduction

It has been indicated that inquiry learning process can be highly demanding for students and that students often refrain from seeking help from the resources (e.g. teacher, peer learners, computer) available in a classroom when they are stuck which may further hinder learning (van Joolingen et al., 2005). Not asking for help when it is needed is a phenomenon which is widespread across a variety of educational settings (Aleven et al., 2003). There are indications that help-seeking behaviour is influenced by gender (Newman & Goldin, 1990; Ryan et al., 1998). Females have been found to be more willing than males to seek help in the classroom when they need it (Ryan et al., 1998). Moreover, gender differences in help-seeking may depend on the domain; females have been found to be more worried about their displayed competence in the mathematic classes than the reading classes when asking for help (Newman & Goldin, 1990). However, studies exploring gender implications in collaborative inquiry learning situations regarding help-seeking process and domain-knowledge gains are relatively rare. It has been argued, too, that collaborative working, working with computers and science learning may involve gender factors (Harskamp et al., 2008, Scanlon, 2000). The literature indicates that students behave differently when working in single-gender and mixed-gender groups and that this can have some effects on students' learning outcomes. Overall, several studies have shown that students' achievements in single-gender conditions are superior to those in mixed-gender conditions (Harskamp et al., 2008; Light et al., 2000). At least in studies in the past, males had more positive attitudes towards computers and science, felt more competent in computer-supported tasks, and felt themselves to be entitled to use technology - all factors that might enhance their performance (Greenfield, 1997; Underwood et al., 2000; Whitley, 1997). As regards collaboration and gender, it has been argued that females prefer to work together, whereas males would rather work independently; consequently it has been thought that collaborative learning may favor females (e.g. Harskamp et al., 2008). It should be noted, however, that these earlier studies on students' help-seeking behavior mostly investigated student-teacher interaction in teacher-centered classrooms – locations where students are expected to ask help from the teacher, and where the teacher is assumed to be the only reasonable source of help. In classrooms focusing on computer-supported collaborative inquiry-learning, a number of help sources are available to students; however, up to now, we know little about how these sources will be utilized in a real classroom situation. Despite the increased use of computer-supported collaborative inquiry-learning in education, there are hardly any studies on the help-seeking behavior and learning of gender groups in the collaborative inquiry-learning classroom.

In this study, we investigated how computer-supported collaboration in single-gender vs. mixed-gender pairs might affect both help-seeking processes and domain-knowledge gains in science classrooms. Moreover, we will explore qualitatively if there are differences between single-gender and mixed-gender pairs' ways of working.

Methods

In three secondary-school classes, female and male students were randomly assigned to single- and mixed-gender groups ($N = 35$ pairs; $n = 17$ single-gender pairs: $n = 7$ female-female pairs, $n = 10$ male-male pairs; $n = 18$ mixed-gender pairs). The students in each dyad used a shared laptop computer and worked on a module of the Web-based Inquiry Science Environment (WISE; Slotta & Linn, 2000).

Nelson-Le Gall's (1981) model of the help-seeking process was applied in a quantitative analysis of 35 screen- and audio-capturing videos of the first lessons (four five-minute intervals/90-minute videos). Interrater agreement between two coders ranged between 74% - 98%. Identical pre- and post-tests were used to measure students' knowledge of physics. Domain-knowledge gain was calculated by reducing the pair's mean post-test score by its mean pre-test score and therefore, it could be either positive or negative. Cronbach's alpha was .74

in the pre-test and .80 in the post-test. Further, qualitative approach will be used in order to explore differences between single- and mixed-gender pairs' ways of working (task-relevant/task-irrelevant behavior; Hijzen et al., 2007). We also explore if there are any indications in the data, that females have more problems with computers than males or if there are any differences in interests towards computers and science or collaboration.

Results and Discussion

In this study, we investigated single- vs. mixed-gender pairs' help-seeking processes and domain-knowledge gains in collaborative inquiry-learning environments. The results of the quantitative analyses show that the gender composition of the group had no substantial effect on the pattern of student help-seeking processes in the classroom. Overall, the amount of help sought was rather low ($M = 3.88$, $SD = 2.76$; range from 0 to 10 times) across the four 5-min time samples. The female-female pairs ($Mdn = 20.79$) scored little better in the domain-knowledge gains than the male-male pairs ($Mdn = 16.60$) or the mixed-gender pairs ($Mdn = 17.69$), but there was no statistically significant difference found between the groups, $H(2) = 0.78$, *ns*. Further, qualitative analysis of the single- and mixed-gender groups will be conducted in order to investigate if there are differences between the different gender pairs and their ways of working in computer-supported collaborative inquiry-learning environment.

Taken together, our findings indicate hardly any differences that could be attributed to the gender composition of the pairs. Help was rarely sought by the single-gender or mixed-gender pairs; nor did the pairs differ substantially in the frequency of help-seeking, in the type and content of help sought or in the help source approached. The domain-knowledge gains were generally fairly modest, but the differences that were found between the students could not be adequately explained by whether they had learned with a same-gender or a different-gender learning partner. Of course, the results of this study have to be cautiously interpreted because of the relatively small sample size and hence the relatively small power to identify existing differences.

References

- Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research*, 73(3), 277-320.
- Greenfield, T. A. (1997). Gender- and grade-level differences in science interest and participation. *Science Education*, 81(3), 259-275.
- Harskamp, E., Ding, N., & Suhre, C. (2008). Group composition and its effect on female and male problem-solving in science education. *Education Research*, 50(4), 307-318.
- Hijzen, D., Boekaerts, M., & Vedder, P. (2007). Exploring the links between students' engagement in cooperative learning, their goal preferences and appraisals of instructional conditions in the classroom. *Learning and Instruction*, 17(6), 673-687.
- Light, P., Littleton, K., Bale, S., Joiner, R., & Messer, D. (2000). Gender and social comparison effects in computer-based problem solving. *Learning and Instruction*, 10(6), 483-496.
- Nelson-Le Gall, S. (1981). Help-seeking: An understudied problem-solving skill in children. *Developmental Review*, 1(3), 224-246.
- Newman, R. S., & Goldin, L. (1990). Children's reluctance to seek help with school-work. *Journal of Educational Psychology*, 82(1), 92-100.
- Ryan, A. M., Gheen, M. H., & Midgley, C. (1998). Why do some students avoid asking for help? An examination of the interplay among students' academic efficacy, teachers' social-emotional role, and the classroom goal structure. *Journal of Educational Psychology*, 90(3), 528-535.
- Scanlon, E. (2000). How gender influences learners working collaboratively with science simulations. *Learning and Instruction*, 10(6), 463-481.
- Slotta, J. D., & Linn, M. C. (2000). How do students make sense of internet resources in the science classroom? In M. J. Jacobson & R. Kozma (Eds.), *Learning the sciences of the 21st century* (pp. 193-226). Mahwah, NJ: Lawrence Erlbaum.
- Underwood, J., Underwood, G., & Wood, D. (2000). When does gender matter? Interactions during computer-based problem solving. *Learning and Instruction*, 10(5), 447-462.
- van Joolingen, W. R., de Jong T., Lazonder, A. W., Savelsbergh, E. R., & Manlove, S. (2005). Co-Lab: Research and development of an online learning environment for collaborative scientific discovery learning. *Computers in Human Behavior*, 21(4), 671-688.
- Whitley, B. E. Jr. (1997). Gender differences in computer-related attitudes and behaviour: A meta-analysis. *Computers in Human Behavior*, 13(1), 1-22.

Acknowledgments

The research of the first author is supported by the Academy of Finland. The study was partly supported by the German Research Foundation (DFG).

Engaging Learners in the Identification of Key Ideas in Complex Online Discussions

Jim Hewitt, Clare Brett, Ontario Institute for Studies in Education, University of Toronto, 252 Bloor Street West, Toronto Ontario Canada
Email: jim.hewitt@utoronto.ca, clare.brett@utoronto.ca

Abstract: In online courses, students can quickly generate discussion threads that contain hundreds of notes. Only a handful of these notes may contain significant new ideas. To help students better identify the key ideas in online discourse, we are experimenting with a new software support: a “Recommend” button. This paper describes the different ways that students made use of “Recommend” and the degree to which the facility changed reading patterns in the course.

Objectives

One of the problems in distance education courses is the challenge of identifying important ideas in online discussions. For every note that contains the germ of a useful idea, there may be dozens of notes of limited value. Consequently, conference participants are constantly faced with the challenge of separating the wheat from the chaff; valuable new contributions can be easily lost or overlooked in the complex web of online messages. Sorting through dozens of notes can be a frustrating and time-consuming process. Moreover, once a promising idea is uncovered, it can be difficult to convey its importance to other members of the community.

To support learners in their efforts to identify useful ideas, we have recently experimented with the design of a new software feature called the “Recommend” button. The Recommend button is an on-screen facility associated with every message in a computer conference. When students feel that a particular message contains an idea of value, they can click on “Recommend” to recommend it to their classmates. This causes a small icon to be displayed beside the message’s title, signifying that it is worthy of further attention. As additional people recommend a particular message, the icon becomes brighter. This provides learners with a visual means of indicating the value of these messages.

To explore the utility of the “Recommend” facility, our research focused on the following questions:

1. What is the students’ experience of using this new facility? What do they like, and not like, about the process of recommending notes?
2. How do graduate distance education students make use of the Recommend facility?
3. Is there evidence that Recommended notes receive more attention from students (i.e., they are read and re-read more often) than non-Recommended notes?

Theoretical Framework

The research is theoretically grounded in the knowledge building literature (Scardamalia & Bereiter, 2003, Hewitt, 2004, Scardamalia & Bereiter, 1994). A knowledge building community is a group of people who are dedicated to sharing and advancing their collective knowledge. The focus is on the community’s ideas and the testing and improvement of those ideas (Bereiter & Scardamalia, 2003, Scardamalia & Bereiter, 2003) with the goal of making intellectual progress on challenging problems of understanding. The community’s objective is not to produce a final product – e.g., an essay or a report – but rather to work together to create new knowledge. From an educational point of view, engagement in knowledge building activity necessarily drives personal growth in the form of deeper understandings and engagement in higher order thinking processes. In online courses, students ideally work together collaboratively as a knowledge building community to extend their collective knowledge. One of the key challenges, however, is to identify the ideas that are most promising. The Recommend facility was developed to help the community address that challenge.

Methods

The research was conducted in “Pepper”, a computer conferencing program developed at the Ontario Institute for Studies in Education at the University of Toronto. The “Like” button in social networking programs (e.g., Facebook) served as a model for the Recommend facility. Pepper was modified so that people could click on a small “Recommend” link on the bottom, right-hand corner of a note to indicate that they wished to recommend the note to their peers. The number of recommendations was displayed to the immediate left of the button. Clicking on the button caused a “thumbs-up” icon to be displayed adjacent to the note’s title. As more people recommended a particular note, the thumbs-up icon turned an increasingly bright shade of blue, thus making it easier to identify notes that were widely recommended.

The Recommend facility was tested over a period of 4-5 weeks in two online graduate courses during the January 2010 - April 2010 academic term. Both instructors were highly experienced with computer-

mediated conferencing and the teaching of distance education courses. The two courses followed a similar 12-week format. Each week, students were assigned a set of readings, which they discussed in their online conferences. New conferences were created for each week's readings. The marking schemes in both courses were based upon a combination of written assignments, the moderation of a weekly conference, and participation in online discussions. Course #1 contained 20 students and Course #2 contained 15 students. Both courses explored topics related to educational technology. Data were collected from two sources: (a) Student activity was monitored using log files that maintained time-stamped records of each student's actions. These data were examined to determine whether students were spending more time examining recommended notes than other notes. (b) Student focus groups served as a second source of data. The focus group meetings were digitally videotaped and transcribed.

Summary of Results

Space does not permit the detailed presentation of all the results from this study. However, here are some of the principal findings:

- To determine whether or not Recommended notes attract attention, we examined the log data to determine how often students opened Recommended and non-Recommended notes. In both courses, students examined Recommended notes significantly more frequently ($p < 0.01$).
- In the focus group interviews, students reported that they felt the Recommend button was a useful addition to their course. It was notable, however, that their appreciation of the feature appeared to be grounded in social rather than cognitive factors. Students liked having their notes recommended by their peers. They felt it validated their ideas and made them feel closer to their classmates. Thus, the feature appeared to promote a sense of communal cohesion, in addition to helping people more easily identify valuable ideas.
- In a secondary analysis we searched for patterns in the number of Recommendations given and received by students in the two courses. In Course #1, there was no obvious relationship between giving and receiving Recommendations ($r=0.12$). However, in Course #2, a positive correlation was found ($r=0.60$), suggesting that people who give a lot of recommendations tend to receive a lot of recommendations. This may indicate that reciprocity plays a role in some of the recommending.
- A few students reported they were reluctant to use this facility, since a percentage of their final course grade was based on class participation. They were concerned that their participation mark would be determined, in part, through a qualitative and quantitative comparison of students' notes. Consequently, it was not to their advantage to use "Recommend" to promote other people's notes.

Conclusions

In computer conferencing environments, all "notes" are visually similar to one another. In practice, this can make it difficult to single out the notes that contain ideas of value to the class. The goal of the current analysis has been to develop new software supports that allow community members to more easily draw community attention to promising ideas so that these ideas can grow through further critique, analysis and refinement. The Recommend button appears to be successful in terms of focusing greater learner attention on particular notes. However, student concerns about grades may have prevented the tool from realizing its full potential.

References

- Bereiter, C. & Scardamalia, M. (2003). Learning to work creatively with knowledge. In E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merriënboer (Eds.), *Unravelling basic components and dimensions of powerful learning environments*. EARLI Advances in Learning and Instruction Series.
- Hewitt J (2004). An exploration of community in a Knowledge Forum classroom: An activity system analysis. In S. Barab, R. Kling & J. Gray (Eds.) *Designing virtual communities in the service of learning* (pp. 210-238). Cambridge MA: Cambridge University Press.
- Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopedia of education*, second edition. (pp. 1370-1373).
- Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building Communities. *Journal of the Learning Sciences*, 3(3), 265-283.

Acknowledgments

We would like to thank the Social Sciences and Humanities Research Council of Canada for their financial support of this research.

Does News Value Help Learners Sharing Relevant Information?

Anja Rudat, Knowledge Media Research Center, a.rudat@iwm-kmrc.de

Jürgen Buder, Knowledge Media Research Center, j.buder@iwm-kmrc.de

Daniel Bodemer, University of Tübingen, Applied Cognitive Psychology and Media Psychology, Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany, d.bodemer@iwm-kmrc.de

Abstract: Opinion formation requires a specific kind of information processing, consisting of perceiving, elaborating, and sharing of information. To support this information processing, we adopt the news value theory. Value of news is expressed by particular characteristics, ascribed by journalists. A pilot study showed that laypeople can accurately identify the so called news factors. A research program using systematically prepared material will investigate how news factors influence information processing and whether they enhance learning.

Introduction

Information processing in the context of opinion formation contains at least three steps: First, people perceive information from a huge amount of incoming news; second, they elaborate information which they regard as relevant; third, people compare and spread news by talking about them. We believe that these processes are also part of the information processing collaborative learners do to build knowledge. First, collaborative learners perceive, for example, particular knowledge or opinions of others. Then, they elaborate the perceived pieces of information. Finally, they share some of it with others to create common knowledge artifacts. Therefore, our research about information processing for opinion formation might contribute to collaborative learning.

Theoretical Background and Methodology

We propose to draw on the news value theory (Galtung & Ruge, 1965) that deals with particular selection criteria that make events become news, and that is related to Lippmann's (1922) early work on the value of news. From all the events taking place journalists can only perceive a few, and from these few they need to select an even smaller number of events for publishing (or *sharing* them with an audience). By means of so called news factors journalists ascribe certain characteristics to events and thereby give them a value (Galtung & Ruge, 1965). The higher the value, the more it becomes probable that an event will get published as news. Eilders (1997) showed that recipients process news in a very similar way as journalists do. Thus, from all published pieces of information recipients also *perceive* only a few. Furthermore, Eilders found that news factors also affect the *elaboration* of information as measured by memory performance. Ruhrmann and Göbbel (2007) proposed a set of news factors that we adapt for our research: "Relevance", "Proximity", "Prominence", "Personalization", "Aggression", "Negative consequences", "Controversy", "Unexpectedness", "Continuity", and "High status". In the following, news factors are discussed with respect to some underlying psychological concepts to better understand their possible effects on information processing. For example, "Relevance" or "Proximity", are based on the feeling of potentially being involved. "Personalization" refers to processes of identification or role-taking (van Dijk, 1988). Sensational or negative news benefits from the evolutionary tendency to pay attention to unknown things, because they might be dangerous (Davis & McLeod, 2003). This is the case for "Aggression" or "Negative consequences". "Controversy" can stimulate creativity as it presents conflicting positions, and raises attention as it could indicate an important result for society (Eilders, 1997). Messages that are inconsistent with an existing schema surprise recipients and arouse their attention (Schützwohl, 1998); "Unexpectedness" refers to this phenomenon. In contrast, "Continuity", "Prominence", and "High status" refer to familiar stimuli and might therefore attract attention (cf. availability heuristic; Tversky & Kahneman, 1973). Research about information processing with emergent technologies might benefit from news value theory and can potentially adapt it. Microblogging systems, such as Twitter, are therefore appropriate for our research. With microblogging users can *share* information by simply forwarding it to others, so they create content without writing new messages, thereby increasing experimental systematicity and tractability. Although research of news value theory already addressed information processing, there is not yet research using carefully manipulated material with systematically varied news factors. Furthermore, using Twitter situates research questions in the context of Web 2.0 and collaborative learning.

Our research program first explores identification abilities of news factors, and then investigates sharing and elaboration of information in combination with news factors. Experimental studies will show whether news factors improve the information processing and how a group awareness tool could additionally enhance opinion formation. At first, we investigated if news factors are actually generally valid criteria (Eilders, 1997), that means whether laypeople rate information as journalists do and if not, what the differences are. In this first study 43 participants took part (13 males and 30 females, $M = 26.09$ years, $SD = 5.55$). On the basis of communication scientists' ratings, we created a set of 63 short messages about a wide range of topics, and

prepared the messages so that each of them contained particular news factors. These underlying news factors were uncorrelated and balanced in their occurrence. For the study the participants received a short description of news factors, and were subsequently asked to rate all messages with regard to their news values.

Results and Outlook

To measure the agreement between the scientists' and the participants' ratings we refer to the signal detection theory and used the sensitivity index d' . Signal detection theory does not only regard the hits (participants ascribed a news factor that we also ascribed) but also considers the false alarms (participants ascribed a news factor that we did not ascribe). The results indicate that laypeople identify news factors quite well (see Table 1). Sensitivity is high especially for news factors that refer to a cue word, for example a famous name for "Prominence". This corresponds to former findings that recipients do not perceive information in its presented complexity but reduce them to few aspects (cf. Ruhrmann & Göbbel, 2007). Response bias is also indicated by the hit rates and the false alarm rates, and it captures the general tendency to respond yes or no. Most of the news factors were ascribed conservatively, indicating that participants clearly recognized if those news factors would have been present. These findings are a first important step towards an investigation using carefully manipulated material with systematically varied news factors. However, news factors do not only have a diagnostic value, but can also be used to improve information processing. In this regard, learning environments could benefit from the news value theory as information can be presented and varied by news factors. Therefore, news factors can be seen as a way to filter information and influence users' behavior. We plan to develop a group awareness tool that provides visualized feedback of the users' selections and sharing decisions. Research of group awareness and social navigation has shown that visualized information on other users' behavior can influence navigational behavior of users (Buder, Bodemer, Dehler, & Engelmann, 2009). Hence, combining the potential influence of news factors on information processing with principles of group awareness and social navigation might enhance learning and opinion formation.

Table 1: Sensitivity of identification of news factors by the participants.

News factor	Sensitivity d'	Response bias c
Prominence	2.59	0.46
Aggression	2.51	0.46
Controversy	1.71	-0.07
Personalization	1.70	0.37
Negative consequences	1.65	0.44
High Status	1.65	0.01
Relevance	1.22	-0.19
Proximity	1.08	0.48
Continuity	1.07	-0.25
Unexpectedness	0.91	-0.14

$d > 1$ good detection; $d > 2$ very good detection; $c < 0$ liberal response tendency; $c > 0$ conservative response tendency

References

- Buder, J., Bodemer, D., Dehler, J., & Engelmann, T. (2009). SCAN tools for collaborative learning. In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracopoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL 2009 Conference Proceedings, 1*, (pp. 606-615). International Society of the Learning Sciences (ISLS).
- Davis, H., & McLeod, S. L. (2003). Why humans value sensational news. An evolutionary perspective. *Evolution and Human Behavior* 24, 208-216.
- Dijk, T. van (1988). *News as discourse*. Hillsdale: Lawrence Erlbaum Associates.
- Eilders, C. (1997). *Nachrichtenfaktoren und Rezeption. Eine empirische Analyse zur Auswahl und Verarbeitung politischer Information. [News factors and reception. An empirical analysis of selection and elaboration of political information]* Opladen: Westdeutscher Verlag.
- Galtung, J., & Ruge, M. H. (1965). The structure of foreign news. The presentation of the Congo, Cuba and Cyprus crises in four foreign newspapers. *Journal of Peace Research*, 2, 64-91.
- Lippmann, W. (1922). *Public Opinion*. New York: Macmillan.
- Ruhrmann, G., Göbbel, R. (2007). *Veränderung der Nachrichtenfaktoren und die Auswirkungen auf die journalistische Praxis in Deutschland*. Abschlussbericht für netzwerk recherche e.V., [Changes of news factors and effects on the journalism praxis in Germany. Final report for netzwerk recherche e.V.] Wiesbaden: netzwerk recherche.
- Schützwohl, A. (1998). Surprise and schema strength. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24(5), 1182-1199.
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology* 5, 207-232.

Scaling Dynamic Mathematics Reform: Findings from the SunBay Pilot Study

Charles F. Vanover, University of South Florida St. Petersburg, vanover@mail.usf.edu
George J. Roy (1), University of South Florida St. Petersburg, royg@mail.usf.edu
Zafer Unal, University of South Florida St. Petersburg, unal@mail.usf.edu
Vivian Fueyo, University of South Florida St. Petersburg, vfueyo@mail.usf.edu
Nicole D. Collier, University of Georgia, ndc@uga.edu
Phil Vahey, SRI International, philip.vahey@sri.com

Abstract: This paper describes the first phase of SunBay Digital Mathematics Project's attempt to improve the middle school mathematics learning ecology of a large, urban district. A dynamic unit incorporating SimCalc MathWorlds® (Roschelle, Knudsen, & Hegedus, 2009) was scaled up to support efforts to teach rate and proportionality. Findings discuss implementation, professional development, and the power of technology to build support for extended programs of change.

Introduction

Teachers are critical to improving the quality of mathematics education, but the ability of educators to teach mathematics varies across classrooms in U. S. schools. Improving the quality of teaching and learning requires changing the work of professionals at many levels of the educational system (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Roschelle et al., 2010). If teachers are to work more skillfully, the tools teachers use, their pedagogical practices, and the curricular activities they implement in the classroom must improve (Roschelle, Knudsen, & Hegedus, 2009). One of the major questions that educational reformers face is how to build capacity to engage in this improvement work and to ensure these efforts support beneficial change in the classroom. Thus, the authors assume that the challenge of raising the quality of instruction in U.S. schools is a knowledge problem that requires innovation, professional development, and reflective practice at every level of the system from the classroom, to the district, to the university school of education.

This paper reports on the efforts of the SunBay Digital Mathematics Project (SunBay) to create the links needed to use collaborative digital technology to improve the teaching and learning of conceptually focused middle school mathematics in a large, urban school district (SRI International & University of South Florida St. Petersburg, 2010). SunBay is a partnership among a college of education, a public university, a school district, and a non-profit research organization; each organization providing complimentary expertise to the project. The long-term goal of the project is to implement a dynamic, digital middle school mathematics curriculum that will democratize access to the complex mathematics of change and variation, and create a more coherent and fruitful mathematical experience for all learners, including those who have not traditionally been successful in mathematics. As such, SunBay intends to help pioneer the future of mathematics education by creating a national model where every middle school mathematics teacher in the participating district has the knowledge and support to use technology to become an effective teacher of dynamic mathematics.

Summary and Discussion of Professional Development Findings

The SunBay pilot study asked teachers to implement a dynamic unit that had been field tested in Texas (Roschelle et al., 2010). All professional development (PD) offered to support implementation was based on an "inquiry stance on teaching" (Cochran-Smith & Lytle, 2001, p. 47). The summer workshops were adapted from a designed PD experience intended to immerse teachers in the unit's mathematical and technical demands (Roschelle, et al. 2009). Teachers used their laptops to solve problems, and they discussed the mathematics underlying the software's dynamic simulations. Teachers acted as learners and used digital technology to enact SimCalc MathWorlds® core strategy (Predict, Check, and Explain) and deepen their knowledge of the unit's underlying mathematical concepts. They answered questions in the unit's paper workbooks. During the fall, teachers received technical assistance using the SimCalc MathWorlds® software and participated in monthly PD experiences designed to help them implement the unit and support deeper technological, pedagogical, and mathematical learning. Teachers rated the PD sessions highly, with an average rating of 4.5 on a 5 point scale across summer and fall.

Teachers were found to implement the materials with good effect. Prior to implementation, a pre-test was administered to students; immediately after the unit was completed, a post-test was administered. The average pretest score of the SunBay students was statistically identical to the students (i.e., treatment and control) in the Texas study (Roschelle et al., 2010; SRI International & University of South Florida St. Petersburg, 2010). Gain scores to measure student learning were calculated by subtracting each student's pretest score from their posttest score. A final analysis showed the SunBay students' gain scores were also statistically

identical to the SimCalc gain scores in Texas and both were significantly greater than the Texas control gain scores. There was a large and significant main effect in both studies with an effect size of 0.8 (SRI International & University of South Florida St. Petersburg, 2010). Consistent with previous studies (Vahey, Lara-Meloy, & Knudsen, 2009), there was no significant difference in mean student gain score across ethnicities including African-American, Asian, Caucasian, and Hispanic. These results indicate the curricular materials are effective regardless of student ethnicity or prior math knowledge.

Conclusion and Future Research

The purposes of SunBay go beyond implementing software and replacement units. The collaborators intend to create a broad set of materials that allow the district's students to achieve high rates of growth in their mathematical knowledge by regularly interacting with high quality learning technologies. Whereas the presented results show the promise of this approach, they raise important questions about the nature of professional development that might support such an undertaking both in the district and in other sites.

How might professional development and other forms of implementation support be organized so that every teacher in the district uses high quality digital learning technologies and every teacher uses these tools effectively to teach mathematics well? While there is a great deal of research that sheds light on this question (e.g. Resnick, 2008; Penuel, Fishman, Yamaguchi, & Gallagher, 2007), we believe that the deep relationships between the collaborators at SunBay as well the scale and long term nature of our work will allow us to develop further understandings of this topic. How might computer supported collaborative learning environments be implemented broadly and fruitfully for all students' benefit? At a time when this question remains unresolved, it is our commitment that work on SunBay will speak to the international research community and measurably benefit the public school students of the urban district we serve.

Endnotes

(1) Co-first authors.

References

- Blumenfeld, P., Fishman, B., Krajcik, J. S., Marx, R. W., & Soloway, E. (2000). Creating usable innovations in systemic reform: Scaling-up technology-embedded project-based science in urban schools. *Educational Psychologist, 35*(3), 149-164.
- Cochran-Smith, M. & Lytle, S. (2001). Beyond certainty: Taking an inquiry stance on practice. In A. Lieberman and L. Miller (Eds.), *Teachers caught in the action: Professional development that matters* (pp. 45-58). NY: Teachers College Press.
- Penuel, W. R., Fishman, B., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44*(4), 921-958.
- Resnick, L. B. (2010). Nested systems for the thinking curriculum. *Educational Researcher 2010, 39* (3), 189-197
- Roschelle, J., Knudsen, J., & Hegedus, S. (2009). From new technological infrastructures to curricular activity systems: Advanced designs for teaching and learning. In M. J. Jacobson, and P. Reimann (Eds.). *Designs for Learning Environments of the Future: International Perspectives from the Learning Sciences*. (pp. 233-262) New York: Springer.
- Roschelle, J., Shechtman, N., Tatar, D., Hegedus, S., Hopkins, B., Empson, S., Knudsen, J., & Gallagher, L. (2010). Integration of technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 44*(4), 833-878.
- SRI International & University of South Florida St. Petersburg (2010, August). *SunBay Digital Math: Pilot year 1 final brief*. Menlo Park, CA: SRI International.
- Vahey, P., Lara-Meloy, T., Knudsen, J. (2009). Meeting the needs of diverse student populations: Findings from the Scaling Up SimCalc project. In S. L. Swars, D. W. Stinson, and S. Lemons-Smith, (Eds.). *Proceedings of the 31st annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. (pp. 416-424). Atlanta, GA: Georgia State University.

Acknowledgments

SunBay is supported by the National Science Foundation under Grant No. 0437861, and by the Helios Education Foundation, the Pinellas County Schools, and the Pinellas Education Foundation. We recognize Dr. Susan Holderness, Ms. Jennifer Knudsen, Ms. Teresa Lara-Meloy, and Mr. Ken Rafanan for their work on SunBay.

Visual Representations of Videotaped Interactions: Understanding Activity Patterns in the Classroom

Cheryl Ann Madeira, James D. Slotta, University of Toronto, 252 Bloor Street West, Toronto, ON, Canada
Email: cheryl.madeira@utoronto.ca, jslotta@oise.utoronto.ca

Abstract: This design-based research study investigates the development of pedagogical content knowledge (PCK) among nine teacher-participants in three design phases. PCK, central to teacher expertise, has been well documented over several decades. However, its actual development is difficult for researchers to investigate. This paper offers perspectives in the uses of video for design-based research on teacher professional development. The findings presented focus on video data and illustrate how teacher patterns of interactions changed from iteration 1 to iteration 2. A methodological strength is derived from an approach to coding teachers' actions and lays out a possible foundation for professional development models.

Introduction and Objectives

Video is an important tool for collecting data about complex learning environments and offers a unique perspective into the instructional moves and pedagogical patterns in which teachers engage (Sherin & van Es, 2005). Analysis of video is problematic, however, as it involves time-consuming transcription, and typically requires coding schemas that are drawn from ethnomethodologies (Koschmann et al., 2009). This poster paper outlines one case study that uses an approach to video analysis of classroom interactions that reveals the spectrum of pedagogical patterns occurring within any given class session. The main research question addressed within this paper is concerned with the relationship between teachers' activities in the classroom and their developing pedagogical content knowledge. The data presented is part of a larger, three-year design-based study that investigated teacher knowledge development through the interventions of scaffolded reflection and peer-exchange.

Inquiry Learning

Teacher actions within a classroom depend on the nature of their instruction. Lecture-based courses will obviously reveal a quite distinct pattern of interactions than small group collaborations, or other forms of inquiry-oriented instruction. Project-based learning is seen as one of the more accessible forms of inquiry (Krajcik & Blumenfeld, 2006) where teachers engage students in a well defined "project approach" that fosters student understanding of science ideas as they develop some artifact or event, typically in collaboration with peers. One interesting characteristic of project-based learning and inquiry learning in general is the student-teacher interactions that occur within a classroom during the enactment of any lesson. To better understand a teacher's enactment of his or her inquiry lesson, it would be of interest to capture such patterns and represent them visually for purposes of coding or comparison.

Video Capture of Classroom Activities

Video offers a way to capture actions and interactions within the classroom to serve as data for research studies of inquiry methods and to help researchers develop an understanding of the learning processes that occur. Given the iterative nature of design-based studies (Barab et al., 2006), video data becomes an important source of information to reveal the impact of design features and improvements between iterations. This poster paper describes an analysis, derived from previous work reported by Stuessy (2005), and illustrates its application of one teacher who planned, enacted, and revised a project-based lesson. Many hours of video data were captured for iteration 1 and 2 and an efficient analytic method was required to allow the determination of salient information about student-teacher interactions for each classroom session.

Methodology and Participant

This poster-paper presents a teacher case-study drawn from a larger iterative, design-based study where science teachers ($N=9$) design, enact, and revise a technology-enhanced, project-based lesson. This case-study highlights one teacher who has 11 years of expertise in teaching physics. Charlie (pseudonym name) co-designed his lesson with a mentor, a doctoral student with 17 years of teaching experience at the secondary science level.

Video Capture of Lesson Enactment

Video documentation (supported by field notes) was used to capture distinct types of actions: small group interactions (SGI) where the teacher interacted closely with small groups of students; large group interactions (LGI) where the teacher lectured the whole class; and isolated actions (Iso) where the teacher was working alone on grading or some other task during class time. Both SGI and LGI were subdivided into classroom

management (M), pedagogical (Ped) interactions, and logistical (Log) support (e.g., setting up the apparatus). That is, a teacher could have whole class, or small group interactions that were coded as M, Ped, or Log, depending on the audio and video content of the interaction.

Each class period, video data was segmented into four main parts (e.g., beginning of class, middle of class, etc.). Segment 1 was the beginning of the class. Then, according to the categories described above, a measure of the amounts of time spent in the various forms of interaction was taken. The video coding was limited to a supportive view of a teacher's patterns of interaction within their lesson enactment (e.g., How much time was spent at the front of the room?). Such questions can be addressed qualitatively through examining graphical representation of the percentage of class time spent on various forms of activity, adapting Stuessy's (2005) method of video segmentation.

While all teacher enactments of all lessons were videotaped. For present purposes, videotapes of only one teacher's classroom enactments are shown in order to illuminate patterns of practice in the classroom.

Analysis and Findings

Stuessy (2005) developed a methodology for representing the pedagogical characteristics of classroom instruction. She introduced an innovative graphical representation that displayed several important factors concerning both student and teacher activities. This allowed for a symbolic representation of the flow of activities, the emphasis on small group or whole class instruction, the activities engaged in by students, and the qualitative nature of student-teacher interactions. Such a video coding system was adapted in order to allow some insight into the student-teacher interactions that occur within the classroom. Project-based learning focused on student collaborations and interactions about physics, and therefore video followed specific patterns such as teachers engaging in small group interaction (SGI) for management or pedagogy helping content development, or large group interactions (LGI) for management or pedagogy, enabling a more complete understanding about teacher project-based processes within classrooms.

The following patterns of video segments compare Charlie's enactments (see Figures 1 and 2). Seen in second video enactment figure 2, there are changes in the level of small group interactions. In Day 4, Charlie incorporates more small group interactions, so that student groups begin to discuss and dialogue right away about the science topics. Charlie's change in practice to include more small group interactions was also representative of a conscious effort from Charlie to listen to students, and to provide students with as much time as possible to organize their understanding about the science concepts. The patterns of Day 1 influenced Charlie and were illustrated in the lesson plan revisions, reflections, and then the enactment patterns of Day 4.

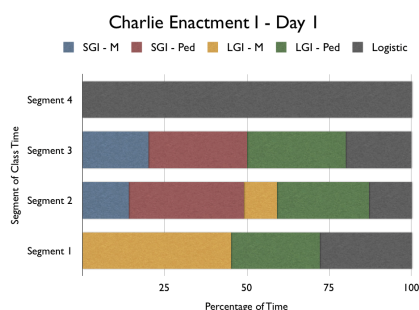


Figure 1. Charlie's Video Enactment Day 1—Iteration 1.

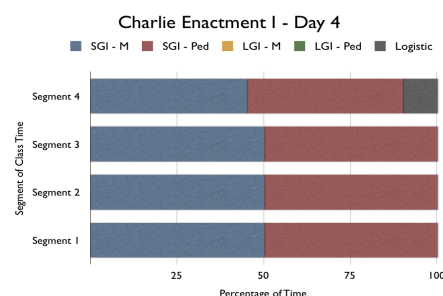


Figure 2. Charlie's Video Enactment Day 4—Iteration 1.

Conclusions

Visual representation of the video capture helps researchers understand the types of interactions that occur within the classroom and provides insights into classroom practices. Teachers that were engaged in small group interactions had better quality lesson plan and reflected deeply about their practice. A visual representation about teacher enactment helped identify when and how teachers could adjust their interactions and practices.

References

- Barab, S. A. (2006). Design-based research: A methodological toolkit for the learning scientist. In K. B. Sawyer (Ed.), *The Cambridge Handbook of The Learning Sciences* (pp. 153–169). New York, NY: Cambridge University Press.
- Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317–333). New York, NY: Cambridge University Press.
- Sherin, M.G. & van Es, E.A. (2005). Using Video to Support Teachers' Ability to Notice Classroom Interactions. *Journal of Technology and Teacher Education*, 13(3), 475-491.
- Stuessy, C.L. (2005). Theoretical framework: Multiple representations, modeling, and modeling practice. In C.L. Stuessy, J. Parrott, & Foster (Eds.), *Looking inside: Videotape analysis of classroom learning environments. Preconference workshop presented at the National Association for Research in Science Teaching Dallas, TX.*

Modeling Efficient Grounding in Chat-based CSCL: an Approach for Adaptive Scripting?

Michael Oehl, Hans-Ruediger Pfister, Leuphana University of Lueneburg, Wilschenbrucher Weg 84a, 21335 Lueneburg, Germany,
Email: oehl@uni.leuphana.de, pfister@uni.leuphana.de

Abstract: Adaptive or intelligent scripting is a promising new approach to computer-supported collaborative learning (CSCL). Such collaboration scripts need mechanisms to adapt to the learners' progress and to assess the learners' evolving interactions. However, researchers are still facing many challenges how to model this process effectively. In our current study we applied a probabilistic approach to model efficient and inefficient communicative processes in chat-based CSCL.

Introduction

Adaptive or intelligent scripting is a promising new approach to computer-supported collaborative learning (CSCL). Such collaboration scripts need mechanisms to adapt to the learners' progress and to assess the learners' evolving interactions. However, researchers are still facing many challenges how to model this process effectively. In our current study we applied a probabilistic approach to model efficient and inefficient communicative processes in chat-based CSCL based on the grounding theory in linguistics according to Clark (1996). Especially chat-based CSCL often suffers from grounding deficiencies. Collaboration scripts in general vary according to the degree of flexibility of the implemented tools. With respect to the optimal degree of coercion the designer is confronted with a dilemma: a lack of coercion may affect the functionality of the script, whereas a surplus could lead to a phenomenon called over-scripting resulting in sterile, constrained interactions and an increased cognitive load for the contributors. An approach recently discussed is the development of highly flexible and *adaptive scripts*, providing support in terms of visualizations and feedback mechanisms exclusively in situations, when it is necessary. Prospectively it might be possible to implement a computer-supported detection of structural elements and patterns characteristic for deficient communication processes, resulting in an intelligent and adaptive script to foster grounding and thus learning processes. Such collaboration scripts need mechanisms to adapt to the learners' progress and to assess the learners' evolving interactions.

A promising approach to the automatic identification of suboptimal communication and grounding processes in CSCL are probabilistic models such as *Hidden Markov Models (HMM)*, used e.g. by Soller (2004) in a rather coercive script. For each sequence of tokens (e.g., a specific sequence of speech acts) a model can be computed consisting of a fixed number of states, initial probabilities, transition probabilities and output probabilities for the tokens (Rabiner, 1989). Additionally, the probability of a specific sequence of tokens being generated by this model can be calculated as well.

The long-term objective of this research is an adaptive CSCL script automatically promoting and facilitating grounding processes and thereby group cognition and learning in chat-based learning groups. For now in a first step the aim of the current study is to model efficient and inefficient chat discourses in a rather free chat environment.

Method

Students ($N = 118$; 70.10% female; age: $M = 25.03$ years, $SD = 4.07$) volunteered as participants and were randomly assigned to 33 learning groups, consisting of three or four members. Participants were instructed to learn about the mechanisms and causes of the Chernobyl nuclear power plant disaster using the ConcertChat interface (Mühlpfordt, 2006). We reported the learning results and preliminary grounding analyses in Pfister and Oehl (2009). For the current detailed process analyses of the *chat discourse structures* and the *grounding processes* with HMM, each contribution was rated according to a coding scheme of grounding activities based on Beers, Boshuizen, Kirschner and Gijssels (2007). The original scheme by Beers et al. (2007) was specially developed to capture the negotiation of common ground in CSCL. However, to fit the characteristics of our study, some modifications had to be made resulting in a coding scheme of five categories with regard to grounding activities:

- (1) Initiation: A new topic in form of a statement or a question is introduced.
- (2) Verification: Information is requested about a previous contribution.
- (3) Response: A content-related reaction to an initiation or verification.
- (4) Positive feedback: A positive reaction (e.g., expression of intelligibility or agreement).
- (5) Negative feedback: A negative reaction (e.g., expression of unintelligibility or disagreement).

It was evaluated and optimized in a validation process and achieved a good inter-coder reliability (Cohen's kappa) of $r = .85$, $p < .001$ between three coders.

The best and worst quartile (25%) of the groups with regard to the learning results (Pfister & Oehl, 2009), each eight groups, was used for further discourse analyses and to generate a HMM on the one hand for efficient learning discourses and on the other hand for inefficient chat discourses.

Results and Conclusion

Thread-based analyses showed that efficient groups' discourses contained significantly less different threads ($M = 10.08, SD = 2.78$) than discourses of inefficient groups ($M = 12.93, SD = 4.13$) $t_{(409)} = 8.22, p < .001$. But these discourse threads in the efficient groups were more in-depth ($M = 2.75, SD = 0.72$) than in the inefficient groups ($M = 2.21, SD = 0.49$) $t_{(409)} = -8.88, p < .001$. The occurrence of the five grounding activities in efficient versus inefficient discourses was significantly different $\chi^2_{(4)} = 16.41, p < .005$. Based on these differences of grounding activities the modeling of the HMM revealed some noticeable differences regarding the discourse structure (efficient vs. inefficient) as shown in figure 1.

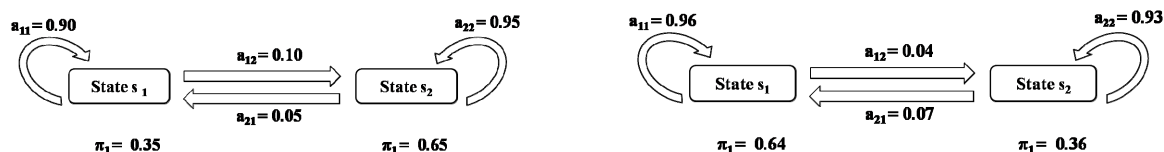


Figure 1. HMM for Efficient (Left) and Inefficient (Right) Grounding Discourses.

In order to specify the differences between the models, the output probabilities of grounding activities as displayed in table 1 have to be considered. The different initial probabilities (π_i) of the two HMM discourse models were salient, i.e., the initial probabilities in the model for the efficient discourses had a high tendency that the group starts its grounding discourse in state s_2 ($\pi_2 = .65$), remains in this state ($a_{22} = .95$) or gets in the discourse process from state s_1 into s_2 ($a_{12} = .10$). Especially the probabilities of grounding activities in state s_2 within the *efficient chat* discourses (table 1) might be interpreted as an almost prototypical grounding process, i.e., an initiation is followed by a response and again grounded by positive or negative feedback. In contrast to this, the more likely state s_1 within the *inefficient chat* discourses resembles rather incomplete grounding with lacking feedback in communication (table 1).

Table 1: HMM probabilities of grounding activities in efficient and inefficient group discourses.

Code	Efficient		Inefficient	
	State 1	State 2	State 1	State 2
Initiation	.25	.53	.40	.49
Verification	.14	.01	.05	.00
Response	.55	.21	.50	.37
Positive Feedback	.00	.17	.00	.10
Negative Feedback	.06	.76	.05	.03

Taking together, even though HMM are a promising approach with respect to assess the learners' evolving interactions for intelligent or adaptive scripting in chat-based CSCL, they raise methodical questions. We will discuss these issues of modeling grounding processes as well as we will outline implications for further research and application.

References

Beers, P. J., Boshuizen, H. P. A., Kirschner, P. A., & Gijssels, W. H. (2007). The analysis of negotiation of common ground in CSCL. *Learning and Instruction, 17*, 427-435.

Clark, H. H. (1996). *Using language*. Cambridge, UK: Cambridge University Press.

Mühlpfordt, M. (2006). *ConcertChat* [Computer software]. Retrieved February 8th, 2011, from http://www.ipsi.fraunhofer.de/concert/index_en.shtml?projects/chat.

Pfister, H.-R., & Oehl, M. (2009). The impact of goal focus, task type, and group size on synchronous net-based collaborative learning discourses. *Journal of Computer Assisted Learning, 25*, 161-176.

Rabiner, L. R. (1989). A tutorial on Hidden Markov Models and selected applications in speech recognition. *Proceedings of the IEEE, 77*(2), 257-286.

Soller, A. (2004). Understanding knowledge-sharing breakdowns: A meeting of the quantitative and qualitative minds. *Journal of Computer Assisted Learning, 20*(3), 212-223.

Pearls of Wisdom: A Computational Scaffold for Design and Diffusion of Cognitive Artifacts

Robbin Chapman, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Building 7-231, Cambridge, MA 02139, rchapman@mit.edu

Abstract: Critical learning involves relating old and new knowledge, and problem solving within unfamiliar domains. Learning through articulation of learning experiences within a social context improves our ability to navigate complex, ill-structured situations. Pearls of Wisdom software is used to facilitate learner engagement in critical learning through the design and sharing of cognitive artifacts called Pearls. An empirical study details how designing and sharing Pearls facilitated critical learning at individual and community levels.

Overview

Designing is authentic and ill-structured, and involves working with a variety of materials, tools, and ideas. Learning by design is analogous to learning embedded within the design process as design activities engage learners in a cycle of designing, evaluating, and redesigning (Perkins 1986). Just as Dewey (1933) theorized reflection to be important to learning, reflection embedded with the design process becomes a dialogue between the learner, her or his reflective process, and the world (Chapman, 2009). Designing affords opportunities for reflection but those episodes are transient and generally focus on performance enhancement. Learners rarely revisit their work to reflect on design and learning processes, and may not intuitively know how to engage in critical reflection. Most learners will require scaffolds for reflection. I introduce the Pearls of Wisdom software toolkit, a computational scaffold for designing and sharing of cognitive artifacts called Pearls, which capture learners' reflections within concrete, artifacts that may be refined and shared. Pearls capture learners' problem-solving, design, and meta-learning strategies as they critical reflect on their project design processes.

The Pearls of Wisdom Toolkit

The Pearls of Wisdom software was designed to help learners create a reflective artifact called a Pearl. Critical reflection is facilitated by scaffolding learner reasoning and decision making about *how* and *what* to share about their project design and learning experiences. The majority of the Pearl interface is organized in three sections that function as a design canvases. Pearl content may include text, graphics, video, source files, links to other Pearls, and various other media. Learners are prompted to think about meta-cognitive and functional aspects of their project. During these activities, they also make decisions about Pearl content creation and organization, layout design, and relevant media to include. The canvas appearance and prompts may be altered by the learner as they gain fluency with the process of articulating their reflective and design processes.

Methodology

Research question included: *how do cognitive artifacts enhance critical reflection on learning experiences and how do these artifacts diffuse throughout a learning community?* Examinations focused on how learners negotiated the Pearl design process, the characteristics of the resultant Pearl corpus, and how Pearls propagated throughout the learning community. We utilized a design-experiment methodology as proposed by Brown (1992). The study took place at the Computer Clubhouse (<http://computerclubhouse.org>), an after-school technology center for underserved 10 to 18-year-olds, located at the Boston Museum of Science, in Boston, MA. Clubhouse members work on self-motivated projects utilizing expressive technologies, including graphic and multimedia software, video technology, and music studio equipment (Kafai, Peppler, & Chapman, 2009). 305 Computer Clubhouse members participated in the study. Cases studies were conducted and data collected, including observational field notes, artifacts (member projects, Pearls, and emails), surveys, interviews, and Pearls of Wisdom system analytics. Quantitative data included scored Pearls and Clubhouse projects, surveys, and system usage analytics. Pearls were scored using a rubric grounded in constructionist project and portfolio evaluation research (Barab and Kirscher, 2001). Projects were scored using a rubric developed specifically for evaluation of Computer Clubhouse projects by the Center for Children and Technology (2002). Surveys, designed to evaluate the learning and meta-learning experiences of study participants, were grounded in the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1992). Qualitative data included observational field notes and interviews. Field note validation was accomplished via participant checking (Stake, 1995).

Data Analysis and Results

Study variables of interest to evaluation of learning environments were identified with a focus on salient characteristics of learner reflective activity, reasoning about learning strategies, effects of cognitive

apprenticeship, and persistent learning strategies. The Pearl corpus was populated with 78 Pearls and with 2,764 Pearl page views over the course of the study. 63% of the Pearl corpus included some dimension of critical reflection. 15% of the corpus was comprised solely of critical reflection content. Critical thinking attributes included problem solving, design opinions, incorporation of other perspectives, meta-cognition, making connections between old and new knowledge. Articulation of project problem-solving strategies was seen in 14 (18%) of Pearls. Statements regarding Pearl or project inspiration or design esthetic decisions were incorporated in 19 (24%) Pearls. Members discussed others' points of view within Pearl narratives in 7 (9%) Pearls. They described problem solving processes in 23 (29%) Pearls. Learners articulated how they made connections between old and new knowledge in 13 (17%) Pearls.

Discussion

A pedagogical goal for Pearl construction was to induce learner reflection by posing a design challenge that required critical reflection to resolve. Integration of Pearl construction and project design situated critical reflection directly into the heart of Clubhouse activities. Members were engaged in an ever-deepening process of explicitly thinking about their learning. That process was provoked by a desire to resolve Pearl design challenges and obstacles, where learners used cognitive and meta-cognitive strategies to resolve incongruities. They became immersed in a protracted project review process that slowed them down, creating a space to think critically about their learning. They also began to give more consideration to the esthetics, content, and complexity of their Pearls, and reported changes frequently motivated by feedback from Pearl users.

Conclusion

Using Pearls of Wisdom learners engaged in critical reflection in ways that made sense for their individual learning styles, and how they learned and made design decisions. They gained fluency in articulating those reflections. I argue that the construction of *concrete representations* of critical reflection serves to motivate learning and reflective interactions between learners, their reflective artifacts, and their learning environment (Chapman, 2009; Chapman, 2004).

References

- Barab, S., & Kirsher, D. (2001). Rethinking Methodology in the Learning Sciences [Special issue]. *The Journal of the Learning Sciences* 10(1&2), 5-10.
- Brown, A. (1992). Design Experiments: Theoretical and methodological challenges to evaluating complex interventions in classroom settings. *The Journal of the Learning Sciences* 2(2), 141-178.
- Center for Children & Technology, Education Development Center, Inc. (2002, September). *Evaluation of the Intel Computer Clubhouse Network, Year 2 Report*. Newton, MA:Pryor, T. & McMillan Culp, K.
- Chapman, R. (2004). Pearls of Wisdom: Social Capital Building in Informal Learning Environments. In M. Huysman & V. Wulf, (Eds.), *Social Capital and Information Technology* (pp.301-332). Cambridge, MA:MIT Press.
- Chapman, R. (2009). Encouraging Peer Sharing: Learning Reflections in a Community of Designers. In Y. Kafai, K. Peppler, & R. Chapman (Eds.), *The Computer Clubhouse: Constructionism and Creativity in Youth Communities* (pp.81-89). New York, NY:Teachers College Press.
- Dewey, J. (1933). *How we think*. Boston, MA:D.C. Heath & Co.
- Perkins, D. (1986). *Knowledge as design*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1991). *A manual for the use of motivated strategies for learning questionnaire: MSLQ*. Ann Arbor, MI:National Center for Research to Improve Postsecondary Teaching and Learning.
- Stake, R. E. (1995). *The Art of Case Study Research: Perspectives on Practice*. Sage Publications.
- Vygotsky, L. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA, Harvard University Press.

Making Meaning and Building Understanding Online: Designing an Innovative and Participative Assessment

Gabriel B. Reedy, King's College London, gabriel.reedy@kcl.ac.uk

Abstract: In an innovative, design-based assessment project for an open access and distance Business Studies programme, students are encouraged to work in small groups using online tools to complete both shared and individual tasks. The course is designed to reflect the real world of business, while encouraging students to build knowledge collaboratively. The context of the course is explained, theoretical approaches influencing the design of the assessment are discussed, and ongoing further enquiry is outlined.

Designing Collaboration in Distance Learning

Progressive pedagogies have gradually changed the learning experience in classrooms at all educational levels. Students frequently work together on group projects, which involve both individual and collaborative work, and these can have a number of benefits for student learning. However, notwithstanding the widespread use of online forums, it has been harder to encourage collaborative working in online and distance learning environments, where learning is often still conceptualised as an individual endeavour.

The notion of using collaborative activity as a key part of assessed work, though again relatively common in face-to-face classrooms, is usually avoided in distance learning settings. Conducting a project-based assessment with a group of online students at a distance presents a myriad of logistical and technical problems that many distance educators would prefer to avoid.

Further complicating the picture is the call for educators to make their programmes more relevant to students, and to create learning experiences that reflect the fields and disciplines under study. In the case of Business Studies, for instance, it is fairly common for practitioners to work in geographically dispersed, cross-functional teams, which work together to accomplish a shared goal.

Description of the Project

A recent design-based project (The Design-Based Research Collective, 2003) at the Open University (OU) in the United Kingdom created a collaborative, project-based assessment for a course on its open-access, distance-learning, undergraduate Business Studies programme. In addition to some of the issues outlined above, the course team was also concerned with what it means to be a business practitioner, and how that practice can be represented and assessed in a meaningful and genuine way. For instance, in the real world of business, working in a team is rarely a simple and structured experience with clearly laid-out tasks or workflow systems. The design of the assessment attempted to create a more genuine learning experience, reflecting the interpersonal and dynamic nature of working in business organisations.

This poster explores various aspects of the design of the assessment, and the theoretical justification for those design decisions. Further work, in progress, explores the artefacts and the outcomes of the work of over 400 students in the first presentation, in an attempt to understand the nature of the interactions and the learning processes that happen in the process (Bransford, Brown, & Cocking, 1999).

Student Experience

The assessment consists of four basic stages, and each corresponds to a week's work for students. During the first stage, students are asked to choose a field of work, an organization, or a job that they aspire to, and begin their online research on what it might be like to work in. Simultaneously, in the group activity, students start to work together to come up with their own agreed list of criteria for how they might judge and assess the evidence they are collecting. The group process prompt is a similar list from survey conducted by a national professional organization.

Continuing that negotiation process into the second week of the activity, students finalize their list of criteria and their chosen research focus, and begin writing an individual report. In the third week, they finish their individual report and post it for their peers to review. Finally, in the last week, each student reviews the work of two colleagues, providing structured and focused feedback based on the learning outcomes of the activity, while receiving feedback from two colleagues on their own work. Using that feedback, students rewrite and augment their work to take into account what they have learned. To reinforce the value of the peer review process, students are asked to write a small reflective paragraph on the feedback process explaining their perspectives on, and use of, the feedback they received.

Design Approaches

The design was influenced by a number of pedagogical theories and approaches, a few of which are outlined here; further details are included in the full paper and poster. These approaches are necessarily related to each other, and are often seen as complementary.

Genuine Assessment Reflects Activity in the Field

Assessment is often perceived as a necessary evil that is more useful for teachers and examiners than for student learning (Shepard, 2000). But assessment can also provide students with a chance to try new ways of thinking and working in a low-risk environment. In this case, it was designed to more accurately reflect "real world" activity in the field of Business and Management.

Collaborative Knowledge Creation

The process attempts to help create and foster a sense among students that they can learn from each other. By designing a process that pushes students to each other for their first feedback experience □ and by asking structured feedback of them for their student colleagues □ the activity builds an ethos of collaborative knowledge creation (Vygotsky, 1978). Importantly, peer review gives students not just a chance to learn about their own work, but to learn from what they see in others' work as well (DiPardo & Freedman, 1988; Dochy, Segers, & Sluijsmans, 1999).

Creating a Community of Learners

As one of a series of collaborative enquiry activities over an academic year, this assessment contributes to an environment where students and tutors work together to try and understand what happens in business organizations, and how to analyse business organisations (Brown, 1997).

Metacognitive Strategies for Learning

Metacognitive approaches (Bruner, 1996; Schraw, 1998) define what about a learning activity makes it such, so that students have explicit supports and explanations about what and how they should be learning. In the case of this assessment, each stage is explicitly situated in the context of the overall learning process, as well as in the context of how it reflects the reality of work in the field.

Preliminary Analysis and Further Research

Initial feedback from students and tutors highlighted the powerful learning experience, and the innovative nature of the assessment. Further enquiry is exploring the nature of student interaction, in particular the ways in which students interact in online group settings, and the qualities of student peer feedback.

References

- Bransford, J., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academy Press.
- Brown, A. L. (1997). Transforming Schools into Communities of Thinking and Learning about Serious Matters. *American Psychologist*, 52(4), 399-413.
- Bruner, J. (1996). *The Culture of Education*. Cambridge, Massachusetts: Harvard University Press.
- DiPardo, A., & Freedman, S. W. (1988). Peer Response Groups in the Writing Classroom: Theoretic Foundations and New Directions. *Review of Educational Research*, 58(2), 119-149.
- Dochy, F., Segers, M., & Sluijsmans, D. (1999). The use of self-, peer and co-assessment in higher education: A review. *Studies in Higher Education*, 24, 331-350.
- Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science*, 26(1), 113-125.
- Shepard, L. A. (2000). The Role of Assessment in a Learning Culture. *Educational Researcher*, 29(4), 4-14.
- The Design-Based Research Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, 32(1), 5-8.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Mental Processes*. Cambridge, MA: Harvard University Press.

OASIS: An Online Professional Learning Community for Inquiry-based Teaching

Robbin Chapman, Shaundra Daily, G8four, LLC, 1116 20th Street South #421, Birmingham, AL 35205
Email: robbin.chapman@g8four.com, shaundra.daily@g8four.com

Abstract: OASIS is an online professional learning community to support teachers in learning to facilitate technology-infused, inquiry-based lessons. OASIS enables capturing and sharing of inquiry-based teaching and pedagogical insights through activity modules and teacher community networking. We conducted focus groups and interviews to probe system usability, efficacy of technology implementation, and teacher understanding of inquiry-based teaching methodology. Teachers cited standards alignment, videos with teacher perspectives, inquiry-based activity modules, and community networking as features teachers they intended to use.

Introduction

Inquiry-based curriculum has been shown to develop independent and critical thinking skills, positive attitudes and curiosity toward science (Wilson, et al., 2010). There is a national push toward inquiry-based teaching in schools and high density computing (4:1 down to 1:1 ratio of students to computers) in the classroom. An opportunity exists to utilize these computers for inquiry-based learning, however; teachers need training in how to deliver inquiry-based teaching in these new, complex classroom environments.

Overview

OASIS (Online Application to Support Inquiry-based Science) is a professional learning community intended to support teacher delivery of technology-infused, inquiry-based lessons that *align* with curriculum standards. Some teacher products have focused primarily on developing an online community but without the resources to support teacher understanding of *how* to deliver inquiry-based lessons. OASIS provides media-rich resources and enables dissemination of teacher learning by supporting them sharing their learning experiences and pedagogical insights. OASIS framework has three core components: professional development, inquiry-based activity modules, and teacher community networking. Teachers attend professional development workshops on inquiry-based pedagogical methods. Back in the classroom, OASIS provides support for class preparation, lesson delivery, and interactions with other teachers. Inquiry-based activity modules contain: activity overview, required time and appropriate class grade level, educational standards, teacher preparation information, links to teacher guides and student worksheets, links to related activities, questions for class discussion, comments viewable by other teachers, video(s) of a teacher engaging in the activity with students then reflecting on the experience, and subscriber capability for notification of module updates. The teacher community networking component of OASIS provides social-networking functionality with discussion forums and commenting capability. Teachers may identify others who are teaching particular classes or have similar teaching interests, share teaching insights and strategies, and connect across a broader teacher community in ways they could not without the OASIS technology.

Methodology and Experimental Design

Study aims were to understand how OASIS contributes to: improved teacher understanding of inquiry-based pedagogical strategies, bolstered teacher self-efficacy with inquiry-based lesson delivery, and peer mentoring amongst teachers. Research questions included: do OASIS system features meet the needs of teachers providing inquiry-based science curriculum, and how might OASIS enhance teacher efficacy in using inquiry-based teaching strategies? We employed a participatory design framework focused on developing approaches to reconciling teacher learning and performance disconnects while iterating OASIS design refinement.

The research site was the Junos Elementary School in Birmingham, Alabama. School demographics: 800 students, 97% African American, 2% Hispanic, 1% Caucasian, and a teacher student ratio ranging between 1:24 to 1:30. Study participants were 5th grade teachers consisting of 3 Caucasian females, 1 Caucasian male, 2 African-American males, and 6 African-American females. We conducted observations of inquiry activities before OASIS introduction, and again after OASIS introduction.

We interviewed teachers about the design of OASIS. Then they received an overview of the purpose of the software, a list of the features not included in the early prototype, and a task list that stepped them through the use of the system. They answered questions about the design and usability of OASIS, their desire to use the system, and recommendations for system feature changes or additions. Then teachers participated in professional development workshops to learn how to facilitate each of the six 5E inquiry-based activities. Prior to implementing the activity in their classrooms, they will utilize OASIS discussion forums, community networking, and activity modules to further enrich their pedagogical understanding inquiry-based lesson

delivery. They then utilize the commenting feature to suggest changes to improve lesson delivery. Subsequent surveys and interviews about these simulated OASIS experiences enable us to converge on a more robust and relevant system design.

Analysis

Our independent variable is teacher use of inquiry-based strategies. The Reformed Teaching Practice Observation classroom observation protocol is used to measure the degree of change in delivery of science instruction. Our dependent variable is student engagement. We measure student engagement using adapted measures from the Goal Orientation and Learning Strategies Survey, along three dimensions of student engagement: 1) mastery, 2) performance, and 3) work avoidance. Interview protocols include the Science Teaching Efficacy Belief Instrument and Technology Acceptance Model. Semi-structured interviews follow non-OASIS and OASIS classroom experiences. Questions relate to teacher efficacy of technology implementation and science teaching, and teacher understanding of inquiry-based teaching methodology, and system usability. Students will take a 15-minute unit test using questions from the National Assessment of Education Progress and Alabama Science Assessment.

Results

For the design questions, teachers used a rating scale of “4 = Very Often” to “1 = Never” to indicate their intentions to utilize particular OASIS features. Teachers pinpointed standards alignment ($m = 3.5$, $s = 0.90$) and teacher videos with teacher perspectives ($m = 3.5$, $s = 0.52$) as features they were most interested in utilizing. The activity modules ($m = 3.41$, $s = 0.67$) and commenting ($m = 3$, $s = 0.62$) were features teachers cited they would use “often” to “very often.” The teacher community networking ($m = 2.5$, $s = 0.79$), discussion forums ($m = 2.58$, $s = 0.99$), and online courses ($m = 2.41$, $s = 0.90$) were features teachers said they would use “occasionally” to “often.” On a seven-point Likert scale from “1 = strongly disagree” to “7 = strongly agree”, teachers indicated OASIS is easy to use ($m = 5.83$, $s = 0.93$) and user friendly ($m = 5.83$, $s = 0.93$).

Discussion

OASIS was evaluated for usability and design potential in transforming pedagogy for teaching technology-rich, inquiry-based lessons. Themes emerged regarding the videos that teachers viewed and rated for usability. Regarding the activity module videos, all teachers agreed: they were pleased to be able to observe the use of sensors in the teaching lesson, it was important that they could see an implementation of an inquiry-based lesson, it was critical to observe those lessons and students’ reactions to the lesson delivery, and video incorporating 5E activities was more engaging than those without. Participatory design is critical to developing an OASIS product with broad appeal across a diverse array of teachers. We will use social network analysis to examine and describe the diffusion of the OASIS along three dimensions: diffusion of innovation, diffusion of data or content, and emergent user behavior.

Conclusion

Learning opportunities emerge when people engage each other to find solutions to specific goals. With OASIS, we give teachers opportunities to learn from the system content and each other. OASIS empowers teachers to do something they could not before our technology was available; map their training to how they teach. OASIS aids internalization of inquiry-based learning skills and connects teachers to their community of colleagues. As this project continues, we hope to see an emergent teacher community of practice of exchanging teaching strategies, uploading video and other content to the activity modules, and reflecting of teaching experiences.

References

Wilson, C., Taylor, J., Kowalski, S., & Carlson, J. (2010) The relative effects and equity of inquiry-based and commonplace science teaching on students’ knowledge, reasoning, and argumentation. *Journal of Research in Science Teaching*, 47(3), 276-301.

Acknowledgements

This research is supported by U.S. Department of Education Contract #ED-IES-09-C-0014 0014.

Towards the Identification of Emergent Strategies for Interdependent Collaboration in Complex Tasks

Daniel Greene, Paulo Blikstein, School of Education, Stanford University - 520 Galvez Mall, Stanford, CA, 94305

Email: dkgreene@stanford.edu, paulob@stanford.edu

Abstract: In this study, we describe a pilot investigation of the strategies and behaviors that small groups learn to use to collaborate on a technology-mediated task. Four subjects independently controlled the wheels of a remote-controlled car, and were tasked with driving it through a simple course. Results suggest that effective solutions often involve isolating repeatable behaviors within the system to reduce the complexity and challenge of their task.

Introduction

Networked computational technologies are an ideal research tool to investigate the dynamics of collaboration. While computers are typically viewed in education as pedagogical tools, communication systems, and media for productive work (Lonchamp, 2007; Çakır, Zemel, & Stahl, 2009), they are also useful for collecting data on student behavior patterns, alone and in groups (e.g., Learning Analytics: Blikstein and Worsley, 2011). In this study, we use a technology-mediated learning environment to collect data on subjects' interaction patterns. Collaborative behavior can also be simulated using agent-based modeling (ABM). ABM has been used by scientists to study phenomena such as the interactions of species in an ecosystem, the collisions of molecules in a chemical reaction, and the food-gathering behavior of insects (Bonabeau, Dorigo, & Theraulaz, 1999; Troisi, Wong, & Ratner, 2005; Wilensky & Reisman, 2006). Agent-based models have also been used in social simulations in which humans are the agents, such as voting, segregation, and the spread of a rumor. Participatory simulations, in which real humans play the role of virtual agents, point to ABM's usefulness as a tool for extracting agent-like behaviors from human participants (Wilensky & Stroup, 2002). This work builds on our previous work on a strategy known as Human, Embedded, and Virtual agents in Mediation or HEV-M (Blikstein, Rand, & Wilensky, 2007). HEV-M uses sensory-enabled robotics as the common medium for the interaction of humans and autonomous virtual agents. This research agenda purports to observe the side-by-side interactions of humans and virtual agents in order to understand, model, and improve the performance of both on real-world tasks.

As a first step in this direction, the collaborative task designed for this study used a robotic car only controlled by humans. Four subjects sat side-by-side and *each controlled one wheel* of a small robot car. All were free to observe the car and communicate with each other. Our guiding questions for this study were the following: What would the biggest challenges be for emergent collaboration in very unfamiliar tasks? What would the most effective individual and group strategies be to respond to those challenges, and why? And finally, what can the nature of the challenges and techniques of collaboration tell us about the possibility of the design of virtual agents to emulate collective human behavior?

Method

We constructed a pilot experiment to explore these questions. One group of four graduate student volunteers (two male, two female; ages ranged from 25 to 40) used a set of four laptops running a software platform that wirelessly controlled individual wheels on a robot car. The wheels can rotate forwards or backwards, but they have no ability to steer left or right. Therefore, users can make turns by rotating one or two same-side wheels in the same direction, and the turns can be made sharper by rotating the opposite-side wheels in the opposite direction. To allow for multiple combinations of interactions, the system has built-in redundancy - i.e., *there are several ways to achieve a right or left turn*. Finally, driving the car in a straight line requires at least two wheels on opposite sides turning at the same time.

Our experimental session lasted approximately 40 minutes, and consisted of three parts. First, the subjects were instructed very briefly in the interface and allowed to determine which wheel they controlled. They were then given 20 minutes to drive the car in an S-curve around three obstacles spaced several feet apart. All subjects could see the car at all times. After the task, a short group interview was conducted in which we asked the subjects about their changing strategies over time. Simultaneous video and audio was recorded for the subjects and the car, and all keystrokes and mouse clicks were logged through a central server.

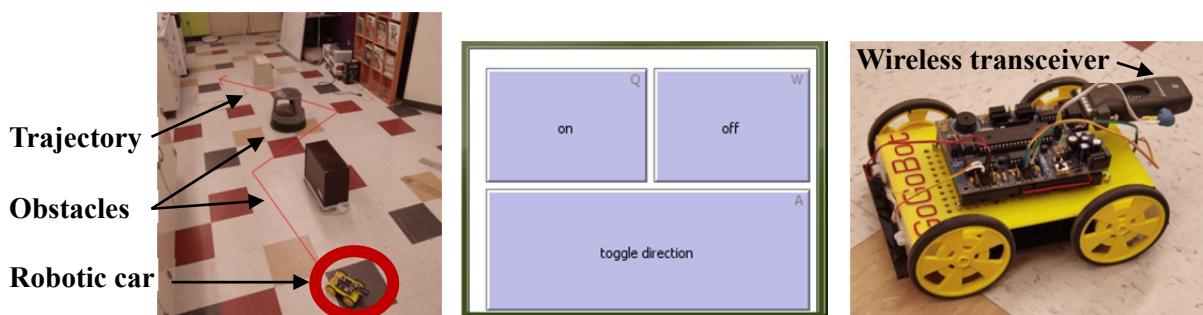


Figure 1. The Experimental Setup (Left), the User Interface for Each Wheel (Center), and the Car (Right).

Analysis and Conclusions

Our analysis identified characteristic challenges created by the nature of the task, the technology used, and the limits of human performance. The primary task challenge was that moving the car in a predictable way required control of multiple wheels. The technology offered a limited interface with a small time delay and inconsistent wheel traction. These challenges were made relevant by the subjects' limited abilities to synchronize their actions, to react quickly, to use the interface, and to remember the orientation of the car.

The solutions and collaboration methods devised by the group also addressed these challenges primarily by grouping and isolating particular sub-goals. For example, the group switched the physical location of two computers at the start of the study, grouping the left and right sides on the left and right side of the table. This would make no difference to a disembodied virtual agent, but it allowed the subjects to devote less working memory to remembering who controlled each wheel. The use of key words like "kill it" and "ready, set, go" also helped the group compensate for technology delays and poor human timing by stopping and starting their input as a team. The overall route planned out by the subjects also reflected a conscious response to the challenges of coordination. The group intended to drive the car in a zig-zag pattern, alternating between periods of traveling straight and turning rather than adjusting on the fly. By simplifying and separating the two components of the car's movement – traveling straight and turning – the group attempted to pull apart the complex system of the car into something more manageable. Overall, we noticed that the subjects' response to a highly dynamic and unpredictable system was not to create complicated coordination schemes or scripted routines, but to identify a very small number of easy-to-execute core behaviors (such as turning off a group of wheels) and dynamically sequence them as needed.

Our findings suggest that collaborative tasks are made easier by the dynamic segregation and organization of work into independent sub-tasks, a principle that is foundational in cognitive science at the individual level (Simon, 1962), and in industrial management at the social level. In other words, subjects' response to the complexity of the task was not to increase complication, but simplicity. It also suggests that realistic virtual agents could be designed by a collection of those simple behaviors, and calibrated with data extracted from networked experiments such as the one we utilized. Future work will continue to reveal the degree to which humans and virtual agents can cooperate in real time in environments with high degrees of complexity and unpredictability.

References

- Blikstein, P. & Worsley, M. (2011). Learning Analytics: Assessing Constructionist Learning Using Machine Learning. Paper presented at the *Annual meeting of the AERA*, New Orleans, LA.
- Blikstein, P., Rand, W., & Wilensky, U. (2007). Examining Group Behavior and Collaboration using ABM and Robots. *Proc. of Agent 2007, Evanston, IL*.
- Bonabeau, E., Dorigo, M., & Theraulaz, G. (1999). *Swarm intelligence: from natural to artificial systems*. Oxford University Press, USA.
- Lonchamp, J. (2007). Linking conversation and task objects in complex synchronous CSCL environments. *Int. Conf. on Web Information Systems and Technology (WebIST'07)*.
- Perit Çakır, M., Zemel, A., & Stahl, G. (2009). The joint organization of interaction within a multimodal CSCL medium. *International Journal of Computer-Supported Collaborative Learning*, 4(2), 115–149.
- Simon, H. A. (1962). The architecture of complexity. *Proc. American Philosophical Society*, 106(6), 467–482.
- Troisi, A., Wong, V., & Ratner, M. A. (2005). An agent-based approach for modeling molecular self-organization. *Proceedings of the National Academy of Sciences*, 102(2), 255.
- Wilensky, U., & Reisman, K. (2006). Thinking like a Wolf, a Sheep, or a Firefly: Learning biology through constructing and testing computational theories-an embodied modeling approach. *Cognition and Instruction*, 24(2), 171.
- Wilensky, U., & Stroup, W. (2002). Participatory Simulations: Envisioning the networked classroom as a way to support systems learning for all. *Presented at the Annual meeting of the AERA, New Orleans, LA*.

GlobalEd 2: a Technology Mediated Simulation Targeted at Writing in the Disciplines

Kimberly A. Lawless, University of Illinois at Chicago, 1040 West Harrison – UMC 147, Chicago, IL 60607, klawless@uic.edu

Scott W. Brown, Mark Boyer, University of Connecticut, 249 Glenbrook Road Unit-2064, Storrs, CT 06269-2064

Email: Scott.Brown@uconn.edu, Mark.Boyer@uconn.edu

Abstract: Leveraging technologies commonly available in most middle grade classrooms, GlobalEd 2 targets an interdisciplinary approach to learning writing, science, and social studies. GlobalEd 2 engages classrooms of students in the simulated negotiation on issues of global concern such as water scarcity and climate change. This presentation details the impact of interactions within the simulation on 420 7th and 8th grade students. Results indicate that after participation in a GlobalEd 2 simulation, students not only increased their writing self-efficacy, but also significantly increased the quality of their written scientific arguments.

Introduction

One key construct shown to mediate academic performance in writing is self-efficacy (Bruning & Horn, 2000; Pajares, 2003; Pajares and Johnson, 1996). Self-efficacy is one's belief that he/she will be able to successfully complete a particular task (Bandura, 1986). A person's self-efficacy (a fluid construct that changes with experience) guides an individual's behavior by determining what he/she attempts to achieve and how much effort is put into his/her performance (Zimmerman & Bandura, 1994). That is, with an opportunity to experience success in a particular task, self-efficacy can be increased. As such, the more opportunities students are afforded to experience success in writing, the more chance there is to positively impact their writing self-efficacy and thereby their writing performance.

This presentation will report the results of a project, GlobalEd 2, developed, in part, to address the concerns regarding general writing self-efficacy and writing performance in the middle grades and specifically writing within the discipline of science. Using a problem-based approach, GlobalEd 2 targets an interdisciplinary approach to learning writing, science, and social studies. Teams of students from different classrooms interact with one another via an online communication system. Each classroom adopts the role of scientific advisor for their assigned country. Country teams operate under the goal of negotiating cooperative agreements within other "countries" participating in the simulation with respect to an issue of international importance such as water scarcity or global climate change. Communications are sent back and forth across teams a proprietary database system in the form of email and instant messaging. As such, communication across teams occurs both asynchronously and synchronously. Through professional development with the teachers, scaffolds and examples provided to the students and modeling of written communication through "planted" sophisticated within the simulation, GlobalEd 2 places a pronounced emphasis on the development of students' writing self-efficacy and their ability to construct evidenced-based scientific argumentation. GlobalEd 2 takes place during the regular school day, and the simulation lasts approximately 12 weeks. For more specific information about GlobalEd 2 and how the larger context of the simulation operates, please visit the website: <http://www.globaled.uconn.edu/>.

Methods

A total of 420 student participated in a GlobalEd 2 simulation during the fall of 2009. 312 of these students were from suburban schools located in New England, the remaining 118 students were from a large Midwestern city. All schools participating were public middle schools, with student drawn from both the 7th and 8th grades. Suburban schools were markedly higher with respect to socioeconomic status with fewer than 15% of participants receiving free or reduced lunches. Students from urban schools were significantly lower socio-economically, with over 80% of student receiving subsidies for lunches. There were 186 males and 236 females combined across both sites, with roughly equal distributions of genders within each site.

Prior to implementing the GlobalEd 2 simulation in their classrooms, teachers from both sites attended a 3-day professional development seminar to help them learn the specific foci of the curriculum, including writing and teaching scientific argumentation. Students within the trained teachers classrooms were asked to complete a battery of pre-test prior to being introduced to GlobalEd2. Within this battery was a 5-item measure of writing self-efficacy (Likert scale format, 1 representing low efficacy and 5 representing high efficacy) and an open ended writing prompt patterned after prompts students receive as part of state mandated standardized tests. This writing prompt asked students to write a persuasive argument either for against the claim that the Earth is in danger of running out of fresh water. They were asked to clearly provide a claim, provide evidence

for their claim as well as the reasoning they used to link that evidence to their claim. Students then began participation in the GlobalEd 2 simulation, which lasted for approximately 12 weeks. After completing the simulation portion of GlobalEd 2, students were re-administered the same battery of assessments as post measures of performance.

Writing self-efficacy items were summed to create one composite score pre and post for each student (possible range: 5-25). Student essays were scored by two independent raters, blinded to student identity and time of administration. An adapted version of the argumentation rubric developed by Midgette, Haria and MacAuthur (2007) was used to rate essays for quality of argumentation. The basic gist of this rubric examines the presence of claims, evidence and reasoning, the completeness of these argumentation chains as well as whether they addressed the opposition in their arguments (possible range 0-5). Given the difficult nature of scoring student arguments (Goldman, 2009), independent rater scores were taken as agreement when they were within one point of one another – this led to 95% agreement. These ratings were then averaged to yield a single argument score for each student's essay.

Results

To address the first research question, regarding writing self-efficacy of the overall sample, pre and post scores were analyzed using a dependent t-test. Results indicated a significant difference between pre and post scores ($t_{(415)}=2.27$, $p<.05$), with students indicating significantly more writing self-efficacy after participation in GlobalEd 2 than prior. This analysis was repeated for research question 2, examining the argumentation quality score derived from the open-ended essay responses provided by students. Results of this t-test also indicated a significant increase in scores from pre to post ($t_{(415)}=9.89$, $p<.001$). To further examine the impact of gender and socioeconomic status on student writing self-efficacy and argumentation quality over time, a series of ANCOVAs were run where pretest scores served as the covariates, post-tests as the dependent variables and gender and socioeconomic status as the independent factors. Results indicated significant differences between both gender and socioeconomic status with respect to writing self-efficacy at the time of the post test after controlling for pre test differences on this construct ($F_{(1,410)}=5.90$, $p<.05$; $F_{(1,416)}=3.97$, $p<.05$). The results show while that students representing each strata changed positively over time, females and students from the urban setting were significantly more self-efficacious with respect to writing than their counterparts at the time of the post-test after controlling for pre-test differences. Regarding argument quality as measured by the open ended essays, no differences in the amount of change by gender or socio economic status were noted.

Conclusion and Implications

The results presented here speak to the potential of GlobalEd 2 as a meaningful context within which students can learn and practice their ability to construct written scientific argumentation. Students who participated in the simulation increased both their writing self-efficacy and their writing performance scores over the course of the curricular intervention. This was the case regardless of gender or socioeconomic status. While there is much still to learn about why this intervention produces these effects on student outcomes, we believe that it centers around the increased opportunities that GlobalEd 2 affords students to construct written arguments in a real world context, the application of knowledge to solve problems rather than recall information and the authenticity of the audience to which they are writing. Curricular implications regarding the utilization of writing intensive, interdisciplinary, problem-based instructional approaches like GlobalEd 2 will be discussed. In addition, supplemental information regarding implementation fidelity and individual classroom performance will be reported.

References

- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bruning, R., & Horn, C. (2000). Developing motivation to write. *Educational Psychologist*, 35, 25-3
- Pajares, F. (2003). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading and Writing Quarterly*, 19(2), 139-158.
- Pajares, F., & Johnson, M. J. (1996). Self-efficacy beliefs and the writing performance of entering high school students. *Psychology in the Schools*, 33, 163-175.
- Zimmerman, B. J., & Bandura, A. (1994). [Impact of self-regulatory influences on writing course attainment](#). *American Educational Research Journal*, 31, 845-862.

Developing Collaborative Argumentation Systems: What Advice Do the Experts Have?

Frank Loll, Department of Informatics, Clausthal University of Technology, Clausthal-Zellerfeld, Germany,
frank.loll@tu-clausthal.de

Niels Pinkwart, Department of Informatics, Clausthal University of Technology, Clausthal-Zellerfeld, Germany,
niels.pinkwart@tu-clausthal.de

Oliver Scheuer, Centre for e-Learning Technology (CeLTech), Saarland University, Saarbrücken, Germany,
oliver.scheuer@celtech.de

Bruce M. McLaren, Centre for e-Learning Technology (CeLTech), Saarland University, Saarbrücken, Germany,
bruce.mclaren@celtech.de

Abstract: The use of computer-based tools to teach argumentation skills has recently become quite popular. To understand the breadth of activity in this area, bridging between published results and real-world development, we conducted a survey in which 97 argumentation experts participated. Based on data from the survey, this paper summarizes the rationale and motivation behind design decisions, important lessons learned, and future research directions.

Introduction

Even though argumentation is essential for “survival” in the modern world, people often have problems in arguing in well-founded ways (Kuhn, 1991). In addition, teaching of argumentation skills is difficult due to the ill-structured nature of argumentation, and not very common, due to limitations in teachers’ time and availability. Computer-based argumentation tools have been one answer to this issue. As a recent review of tools and research reveals (Scheuer et al. 2010), there are a variety of different approaches that have been employed. The review highlights promising attempts to teach argumentation skills, but was limited to published results and available tools, which often do not reveal design decisions and the rationale behind them.

In this paper, we extend prior reported results of a survey aimed at bridging between published results and real-world development by focusing on the development of argumentation systems (some, but not all, of which were collaborative) (Loll et al., 2010a, b). More specifically, we report on what experts in argumentation have learned over the years. By documenting these lessons learned, our goal is to provide guidance for future research and development of educational argumentation systems, particularly those focused on collaborative learning of argumentation.

Methodology

To collect experts’ experiences with argumentation systems, we conducted a web-based survey among selected experienced argumentation researchers, teachers, and developers. The selection was done via a systematic search through the author lists of relevant conferences (e.g., CSCL, ITS, AIED, COMMA, ISSA) and journals (e.g., ijCSCL, IJAIED) and extended by means of additional web searches for experts. In this paper, we will focus on the results of the last part of the questionnaire, which consisted of three open-ended questions regarding the *development of argumentation systems*. Based on self-reported expertise, we asked experienced developers the following three questions:

- (1) In the argumentation system (or systems) that you have designed and/or developed, what would you say was the best feature? Why?
- (2) Can you briefly describe the types of flexibility and/or configuration you provided in the design of your argumentation system (or systems)?
- (3) What would you say was the most important lesson (or lessons) learned in designing, developing and/or testing your argumentation system?

Overall, we received responses from 97 out of 153 invited experts. The experts’ responses were coded by means of a hierarchical tree-based approach independently by two coders resulting in an adequate inter-rater reliability (between 65% and 90%). Remaining conflicts were resolved by discussion.

Results

The “best” argumentation system features (Q1) reported by our experts can be categorized into four groups: First, the *usability of the system*. This includes an appropriate argument visualization, the most frequently mentioned desirable feature. Relatedly, it was frequently mentioned that visualizations with multiple representations (e.g., graphs, tables, threads) are highly desirable. Second, *flexibility and configurability with respect to the underlying argument model* was cited as quite helpful, for instance by means of configurable ontologies (elements available to model the argument). Third, *good pedagogical design* was often mentioned, meaning support for, for instance, group formation and the assignment of roles, micro-/macro-scripting in

connection with fading of scaffolds as well as game features to enhance the participants' motivation. Finally, the provision of *feedback to the argumentation process* was highly cited, including automated feedback and support for manual feedback from moderators and/or teachers.

Whereas flexibility was identified as one of the “best” features, question Q2 clarifies more specifically what is meant by flexibility. Here, one kind of flexibility mentioned was *technical flexibility*, including platform independence, flexible data representation and interface configuration (such as the ability to toggle system features on and off). *Argument model flexibility* was highly regarded, including the manipulation of elements representing argument parts (e.g., shape, size) and their details (e.g., font colors), the definition of constraints to enforce a specific argument structure (such as argument – counter-argument chains), and the use of questions to scaffold the argumentation process. With respect to collaboration, the importance of *a rich repository of collaborative features* was stressed. This includes, for instance, the assignment of roles and associated access rights, the definition of individual and collaborative work phases, and the support of awareness mechanisms, (e.g. an alert whenever a user modifies controlled parts of the argument). Finally, the *flexible support of feedback* was highlighted. Here, the systems either support argumentation directly by giving feedback to the arguers or indirectly by informing a tutor/moderator of possible problems.

With respect to Q3 (i.e. the lessons learned), the majority of the experts agreed on the slogan “*Keep it simple*”. The simplicity of a tool, including the underlying argument model as well as the user interface was widely acknowledged as key to motivation (as less training is required) and – directly connected to it – success of the system. Thus, the provision of additional system features and functions (e.g., AI support, scripts, etc.) should be carefully evaluated before use, as these can increase overall complexity. However, even with a simple system, it is not guaranteed that empirical evaluations of promising approaches will result in success due to the complex nature of argumentation. Connected to this point is the fact that a graphical representation will not automatically lead to improved argumentation skills, per se, but its strength and weaknesses must be considered in combination with a vast set of other factors (e.g., gender, group size, task) that are largely unexplored and will require more in-depth analysis in future.

Discussion & Limitations

The present results support prior findings with respect to collaborative argumentation learning: The process of collaboration appears to be best supported with structural means such as visualizations and ontologies (e.g., Suthers, 2003) and guidance, such as with collaboration scripts (Stegmann et al., 2007). On the other hand, it is essential to walk a fine line between helping learners with many features and keeping things simple. A highly complex and hard-to-use tool can obviously result in cognitive overload and demotivation of learners. To effectively use educational argumentation tools, training of both students and teachers is required. In addition, both teachers and students should be involved in the overall development process in order to recognize problems early.

Regarding the potential of computer-supported argumentation, our results also indicate a trend toward making systems as flexible as possible. With respect to the evaluation of the effect of argumentation systems, one should bear in mind that teaching argumentation skills is usually a long-term process. Thus, short-term evaluation of tools that attempt to foster these skills may not result in significant effects.

References

- Kuhn, D. (1991). *The Skills of Argument*. Cambridge University Press.
- Loll, F., Scheuer, O., McLaren, B. M., Pinkwart, N. (2010a). Learning to Argue Using Computers - A View from Teachers, Researchers, and System Developers. LNCS 6095 (pp. 377 - 379). Springer.
- Loll, F., Scheuer, O., McLaren, B. M. & Pinkwart, N. (2010b). Computer-Supported Argumentation Learning: A Survey of Teachers, Researchers, and System Developers. LNCS 6383 (pp. 530-535). Springer.
- Scheuer, O., Loll, F., Pinkwart, N., & McLaren, B. M. (2010). Computer-Supported Argumentation: A Review of the State-of-the-Art. *International Journal of CSCL*, 5(1): 43-102.
- Suthers, D. D. (2003). Representational guidance for collaborative inquiry. In J. Andriessen, M. J. Baker, & D. D. Suthers (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 27–46). Dordrecht: Kluwer Academic.
- Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating Argumentative Knowledge Construction with Computer-supported Collaboration Scripts. *International Journal of CSCL*, 2:421-447.

Acknowledgments

This work was supported by the German Research Foundation (DFG) under the grant “LASAD – Learning to Argue: Generalized Support Across Domains”.

Learning about Ecosystems in a Computer Supported Collaborative Learning Environment

Sameer Honwad, Cindy Hmelo-Silver, Rebecca Jordan, Suparna Sinha, Catherine Eberbach, Rutgers University, New Brunswick 08901,

Email: sameer.honwad@gse.rutgers.edu, cindy.hmelo-silver@gse.rutgers.edu, jordan@aesop.rutgers.edu, suparna.sinha@gse.rutgers.edu, catherine.eberbach@gse.rutgers.edu

Ashok Goel, Spencer Rugaber, Design & Intelligence Laboratory, School of Interactive Computing, Georgia Institute of Technology, Atlanta, GA 30332,

Email: goel@cc.gatech.edu, spencer@cc.gatech.edu

Abstract: This paper explores how a group of students collaborated in understanding ecosystem processes in a technology intense learning environment. The technology (hypermedia, NetLogo simulations and ACT toolkit) provided opportunities for students to engage with complex phenomena and understand the dynamic nature of the ecosystems.

It is difficult for learners to understand ecosystems as they have not had the opportunity to observe and engage the multidimensional processes of the ecosystem. Computer-supported collaborative learning environments can provide opportunities for students to understand ways of organizing ecosystem understanding, interact with simulations that provide a context for collaborative discussion and engagement, and use modeling tools that provide a focus for negotiation understanding. In this paper we present results from a CSCL learning environment created to help students understand aquatic ecosystem processes. The environment was designed to help middle school students develop a deep understanding of ecosystem processes using a structure behavior and function approach (Goel et al 1996). The SBF approach was applied to an ecosystem model by using the following guidelines: Structure refers to components of an ecosystem that have form. Structures can be macro (e.g., Fish, plants) or micro (e.g., bacteria, fungi) in nature. Behavior represents system mechanisms and processes. Finally, functions are roles the structures play in an ecosystem. The premise of using the SBF approach is that this gives students a framework to gain a deeper understanding about ecosystem processes. Research has shown that students can easily identify structures but it is difficult for them to identify behaviors and functions (Hmelo, Holton, & Kolodner, 2000; Hmelo-Silver, Marathe, & Liu, 2007). Thus in this paper we investigate the extent to which students discuss structure, behavior, and function during the course of the intervention.

Methods

To help students understand complex ecosystems processes, we designed a two week intervention in a public middle school in New Jersey. The unit used aquarium as a model ecosystem and was designed by a team of learning scientists, middle school classroom teachers, and ecologists. The aquarium was set up in the classroom prior to the beginning of the unit. The technology was an integral part of the intervention and consisted of: a function oriented hypermedia, simulations of macro-micro level processes and the aquarium construction toolkit (ACT; Vattam et al. 2011). Throughout the curriculum unit, students worked in small teams of four to five.

The science teacher introduced the unit by asking students their ideas about functions involved in ecosystem processes. The teacher then assigned the students to groups and asked them to use the ACT tool to map their ideas about ecosystems as structures behaviors and functions. The students used the hypermedia to refine their knowledge about ecosystem functions. The students then explored two NetLogo simulations (Eberbach & Hmelo-Silver, 2010). They were then asked to refine their ecosystem models in their groups and finally present to the entire classroom.

Fifty four seventh grade students participated in the activity. However for the purposes of this study we report on talk from one group of four students that were video recorded. They collaborated around one computer, which had the hypermedia, the NetLogo and the ACT. The hypermedia was used to sharpen the student ideas about ecosystems and in the NetLogo simulations students manipulated various ecosystem components (number of fish, amount of food, etc) in order to maintain a healthy ecosystem. We coded each utterance as structure, behavior or function. The data were coded from the first time the students started to use the ACT tool to organize their thoughts as a group in SBF terms, to the time they made their final presentations in the classroom. The students used the NetLogo simulations during this time. An utterance was coded as a structure if any student in the group said a sentence that involved a single ecosystem component. For example an utterance got coded as a structure if the students said "Lets put in fish" or "hey where are the plants?". An utterance was coded as a behavior if the students had more than one component in their talk and they made a linear connection (how) between those two components. An example for an utterance that got coded as a behavior would be "Plants produce oxygen". Finally an utterance was coded as a function if the students gave

an explanation for the process itself (how did the structures do what they did). An example of a function-oriented utterance would be “Fish eat food to get energy”.

Results and Discussion

Initially (day 1; figure 1) the students identified more behaviors than functions. Prior to using the ACT tool, the teacher had discussed a few ecosystem processes with the students. Descriptions of such processes could correspond to behavior. The teacher, however, did not discuss how these processes are linked to broader explanations of ecosystem phenomena, so we were not surprised that students identified more behaviors than functions. We also noted an increase in structures on days three and five. We hypothesize that student engagement with the NetLogo simulations, which model nitrification and carrying capacity could encourage deeper discussions about ecosystem processes. Also on days three and five, students identified more functions when compared to days one and two. We suspect that the NetLogo simulations helped the students understand the mechanisms and the structures to cause the ecological phenomena.

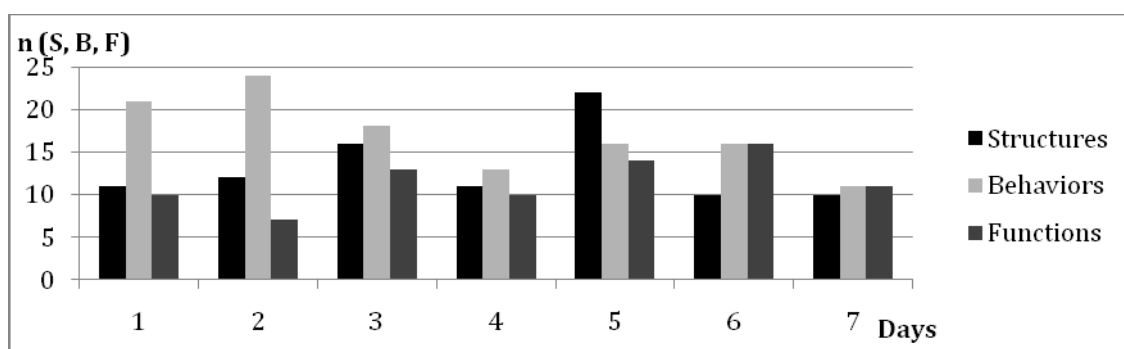


Figure 1. Student Progress (by Day) in Terms of Identifying Structures Behaviors And Functions.

Prior studies have noted that when experts/scientists discuss science they often present their ideas as behaviors and functions (Hmelo-Silver, Marathe & Liu, 2007). As observed in figure 1 the students engage more in function and behavior talk than in structure talk as they move toward the end of the unit. On days six and seven, students refined their models. These are also the days that followed students' engagement in all of the activities (i.e., NetLogo simulations, hypermedia and ACT toolkit). We believe that at that point students are now in a position to finalize their models. Data from days six and seven show that for every structure there are more behaviors and functions. Toward the end of the unit the students are engaging in complex discussions with regard to ecosystem processes. For example while revising their final models the students were having conversations like the one below:

Student 1: Fish eat food and create waste – that's how ammonia gets into the water

Student 2: You mean waste is generating ammonia?

Student 1: Bacteria breaks down ammonia and plants use it to grow

In the above example students are talking about a few structures (e.g., fish, plants, bacteria) yet they are also engaging in behavior and function talk (e.g, bacteria breaks down ammonia and plants use it to grow). Taken together our findings suggest that a combination of using the structure, behavior, and function approach along with a set of carefully designed CSCL tools can support sophisticated student discourse about ecosystem processes.

References:

- Eberbach, C., & Hmelo-Silver, C. E. (2010). Observing the seen and unseen: Computer and social mediation of a complex biological system. In Z. C. Zacharia, C. P. Constantinou & M. Papaevripidou (Eds.), *Computer Based Learning in Science* (pp. 213-224). Warsaw: OELiZK.
- Goel, A., Gomez, A., Grue, N., Murdock, W., Recker, M., & Govindaraj, T. (1996). Towards Design Learning Environments - Exploring How Devices Work. In *Proc. International Conference on Intelligent Tutoring Systems*, Montreal, Canada, June 1996.
- Hmelo, C., Holton, D., Kolodner, J. L. (2000). Designing to learn about complex systems. *Journal of Learning Sciences*, 9, 247–298.
- Hmelo-Silver, C., Marathe, S., Liu, L. (2007). Fish Swim, Rocks Sit and Lungs Breathe: Expert-Novice Understanding of Complex Systems. *Journal of Learning Sciences*. Routledge.
- Vattam, S., Goel, A., Rugaber, S., Hmelo-Silver, C., Jordan, R., Gray, S., & Sinha, S. (2011) Understanding Complex Natural Systems by Articulating Structure-Behavior-Function Models., *Special Issue on Creative Design*, 14(1): 66-81, February 2011.

Collaborative Learning with Scaffolded Dynamic Visualizations

Jennifer L. Chiu, University of Virginia, Charlottesville USA, jlchiu@virginia.edu

Abstract: This study describes collaborative and individual learning for students working with dynamic molecular visualizations. Chemistry students learned about chemical reactions using a week-long project that combined dynamic visualizations with pedagogical tools to support knowledge integration. This study explores how explanation prompts can facilitate collaborative learning with dynamic visualizations using case studies of student pairs. These results have implications for instructional practice with dynamic visualizations and students' use of models and simulations.

Introduction

Dynamic scientific visualizations can help students learn science concepts and inquiry processes in computer-based learning environments. For instance, scientific visualizations enable learners to explore the impact of variables using simulations of complex systems, make complex or emergent processes visible and manipulatable, and enable students to make predictions, test, and refine their understanding. The overall value of instructional scientific visualizations is positive, but there is great variability in learning outcomes (Hoffler & Leutner, 2007). However, there is relatively little research that investigates collaborative learning with scientific visualizations, and the existing research provides mixed results for the impact of visualizations on collaborative learning (Ainsworth, 2008). In some cases, animations may inhibit collaborative learning (Schnotz, Bockheler & Grzondziel, 1999) and in other cases, visualizations may benefit collaborative learning (Rebetz et al., 2009). These varied results may be due to the diverse ways that visualizations are used in instruction, the different designs of visualizations themselves and the domains of the visualizations.

This study builds upon previous work with Chemical Reactions, a Technology-Enhanced Learning in Science (TELS) curriculum unit that combined dynamic visualizations with pedagogical tools in the Web-based Inquiry Science Environment (WISE; Linn et al., 2006). Past research with WISE has found that students who work together in pairs through guided inquiry projects can help each other make sense of science phenomena even when their normative understanding is limited. Students can talk about formative ideas in pairs and offer alternative perspectives and explanations from their teachers or instruction. Students can also build from each other's ideas, helping peers critique and refine their understanding. Students help each other engage in knowledge integration through the process of questioning and explaining instruction.

This paper builds from these studies and explores how guiding small groups' interactions with dynamic visualizations by prompting explanations can impact collaborative and individual learning. Building upon previous research on dynamic visualization, this study explores how prompts that ask students to coordinate representations can support pairs of students to connect ideas. This study explores the explanations generated by students in small groups and how these prompts helped pairs of students connect the visualizations to other related concepts.

Methods

The week-long Chemical Reactions module was designed to help students connect ideas about chemical reactions such as energy, conservation of mass, and limiting reagents on molecular, observable and symbolic levels. A partnership of teachers, researchers and scientists designed and refined the unit to help students elicit, add, revise and reflect upon ideas using the scaffolded knowledge integration metaprinciples of *make science accessible*, *make thinking visible*, *help students learn from others*, and *promote autonomous lifelong learning* (Linn, Davis & Eylon, 2004).

Prior research using Chemical Reactions has tested the efficacy of the curriculum unit involving groups using Chemical Reactions and a comparison group of high school students in chemistry classes (Linn et al., 2006). Increases from pretest to posttests for both the pilot and test groups revealed that students added normative ideas about chemical reactions and made connections among these ideas on symbolic and molecular levels. Regression analysis found that Chemical Reactions students significantly differed from the comparison group, suggesting that students studying the unit outperformed students revising material and retaking the same tests. This study investigates student responses to the embedded explanation prompts about the visualizations to describe the kind of collaborative learning that the prompts may have supported.

Case Studies of Embedded Prompt Trajectories

Selected students' responses based on individual pretest and posttest achievement scores provided a range of the kinds of connections among ideas pairs of students made using the embedded prompts and visualizations. The selection of pairs presented here highlights a range of individual scores from pretest to posttest. This analysis presents a synthesis of the pairs' embedded explanations and corresponding pretest and posttest responses.

Pair 1 both scored above the class average on the pretest and demonstrated strong connections from the visualizations to normative chemistry ideas. For example, when asked about the relationship between the molecular visualizations and the related balanced equations, Pair 1 responded, “They are related because in order to have no atoms left over in the workbench, we had to get a certain amount of oxygen atoms and hydrogen atoms. This number is the same as the ratios in the balanced equation (2 H₂, 1 O₂, and you end up with 2 H₂O molecules).” Pair 1 demonstrated a strong connection between what they have experienced in the visualizations and the concept of balanced equations on a molecular scale. They made connections between chemical reactions and balanced equations through the underlying concept of ratios, and emergent connections between the balanced equation and limiting reagents. Pair 1 significantly gained from pretest to posttest, connecting heat and molecular motion, conservation of mass, and limiting reagents. The explanation prompts may have helped Pair 1 integrate new ideas of conservation of mass and limiting reagents into their repertoire.

Both students in Pair 2 scored below the class average on the pretest. Pair 2’s answers to the prompts demonstrated connections based on color or form from the visualizations to other concepts. For example, when asked about how the balanced equation affects the numbers of product molecules that are made, Pair 2 stated, “You start off with 2purple [sic] molecules, and two blue, bonded molecules. You end up with One purple, and two blu, all bonded.” Pair 2 connected color and number of molecules involved in the activity, but did not connect ideas such as ratios or limiting reagents. The prompts did not seem to help Pair 2 make robust connections to the ideas underlying the visualizations. Pair 2 made very small gains on the posttest and remained under the class average on the posttest.

Pair 3 also scored below the class average on the pretest. Pair 3 demonstrated connections from the visualizations to chemistry concepts in their explanations. For instance, Pair 3 stated, “The balanced equation effected the product molecules by allowing a certain amount of molecules to bond with each other. When some molecules bond with others, some molecules are left alone.” Pair 3 demonstrated emerging connections from the visualizations to the concept of limiting reagents. These kinds of emerging conceptualizations were present in other responses. The prompts seemed to help JG and RB add new information about the visualizations, refine and sort their ideas to make connections to underlying scientific ideas. Pair 3 scores increased from pretest to posttest. Both students demonstrated an increase in their understanding of the connections between the symbolic and molecular representations, conservation of mass, limiting reagents, and the dynamic nature of reactions on the posttest.

In general, pairs that were able to use the embedded prompts to make connections from the visualizations to relevant concepts increased their score from pretest to posttest. These groups demonstrated more integrated understandings of symbolic and molecular representations, conservation of mass, limiting reagents and the nature of chemical reactions.

Discussion and Implications

These case studies illustrate how prompting explanations of the visualizations can help pairs of students make relevant connections from the visualizations to chemistry concepts. These kinds of activities seem to counter the “underwhelming effect” or illusion of understanding that can be associated with dynamic visualizations. By prompting student dyads to explain their understanding of the visualization, students were forced to make their individual assumptions and ideas explicit and engaged in building a shared understanding of the visualization and its meaning. Students sorted out their individual understanding through these discussions with their partners. These results highlight the need for further investigation of the role of metacognition and monitoring of understanding that occurs with collaborative learning with dynamic visualizations.

References

- Ainsworth, S. E. (2008). How do animations influence learning? In D. Robinson, and G. Schraw (Eds.), *Current Perspectives on Cognition, Learning, and Instruction: Recent Innovations in Educational Technology that Facilitate Student Learning*: Information Age Publishing, pp 37-67.
- Hoffler, T., Leutner, D. (2007). Instructional animations versus static pictures: A meta-analysis. *Learning and Instruction, 17*, 722-738.
- Linn, M. C., Davis, E. A., & Eylon, B. –S. (2004). The scaffolded knowledge integration framework for instruction. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet environments for science education* (pp. 73-83). Mahwah, NJ: Erlbaum.
- Linn, M.C., Lee, H. –S., Tinker, R., Husic, F., & Chiu, J.L. (2006). Teaching and assessing knowledge integration in science. *Science, 313*(5790), 1049-1050.
- Schnotz, W., Böckheler, J., & Grzondziel, H. (1999). Individual and co-operative learning with interactive animated pictures. *European Journal of Psychology of Education, 14*(2), 245-265.
- Rebetz, C., Betrancourt, M., Sangin, M. & Dillenbourg, P. (2009). Learning from animation enabled by collaboration. *Instructional Science, 38*(5) 471-485.

Improving Collaboration through Visibility of Students' Learning Products in a Digital Classroom Environment

Juan C. Hernández, Luis F. Maldonado, Widman S. Valbuena, ICONK, Bogotá (Colombia),
Email: juan@iconk.org, lufamagr@iconk.org, said@iconk.org
H. Ulrich Hoppe, University of Duisburg-Essen, Germany, hoppe@collide.info

Abstract: This study addresses the possibility of increasing motivation and learning success in a classroom setting by means of making the intellectual production of students visible. For this purpose, a software program has been developed to support “classroom visibility management”. The approach has been tested with a sample of 80 ninth graders of a public school in Colombia. The collaborative work is analyzed in terms of the observable interactions among students and uses social network analysis as an analytic tool.

Research Objective

Often students working on individual or small group assignments in a classroom environment produce interesting results that are not shared with the whole group. Also teacher feedback tends to be selective and does often ignore the best available student products in a classroom. We believe that the sharing of learning products with supervisors and peers should become a standard practice and attitude, which can be effectively supported by existing community tools. In our case, the Elgg social networking platform has been used to support the visibility and sharing of results in a classroom environment.

Our study is based on two hypotheses: First, the pedagogical management of visibility of the students' intellectual production favors their conceptual development, and second, the visibility of students' learning products in the class stimulates/improves collaborative work. We expect visibility to improve motivation through peer feedback and the building up of reputation or social prestige derived from the contributions (i.e. the learning products) as well from the communicative interactions based on the sharing of these products (cf. Stajkovic and Luthans, 2003). Our study aims at establishing the effect of the pedagogical use of visibility, both in collaborative work as well as in the conceptual development of a group of students. Our research examines the relationship between visibility (independent variable) and conceptual development and collaborative work in a learning scenario (dependent variables).

Theoretical and Methodological Framework

Several authors have used of Social Network Analysis (SNA, see Wasserman & Faust, 1994) to analyze interaction structures and role dynamics among students in a classroom. In this orientation, Martinez et al. (2003) propose a mixed evaluation method that combines traditional sources of data with computer logs, and integrates quantitative statistics, qualitative data analysis and social network analysis in an overall interpretative approach. Similarly, Harrer et al. (2005), following the idea of triangulation, also used qualitative methods, statistical analysis and SNA to explore the patterns of communication for a mixed presence/web-based university course. The results show that while an isolated perspective does not suffice to explain the complex processes, taking more perspectives into account in an integrated way enables a better understanding of technology enabled communication and interaction.

Also based on SNA, Cocciolo et al. (2007) conducted an exploratory study that related communicative processes in a large digital repository with the emergence of an online community of practice. The analysis revealed that the online repository provided opportunities for novices to adopt the role of an expert knowledge facilitator. In terms of learning this study was inspired by the socio-cultural approach of Vygotsky (1978), in which social interaction mediated by language is seen as the main engine of intellectual development. Our hypothesis is that increasing the visibility of results will encourage collaborative knowledge building of students.

Software Environment

Our software platform has been developed to allow students to expose their intellectual products to other learners and supervisors in the classroom and to allow for communication, especially commenting, around these products. The software is a tool for social interaction based on products and value judgments. We have used the Elgg social networking platform together with a MySQL database as a basis for our classroom environment. The design of the specific interface with menus and archive structures was based on a prior participatory paper-and-pencil study with students from the same educational environment. This paper prototype facilitated and pre-determined our design decisions on settings, location of elements, and configuration of new resources.

Once the platform was ready each member was registered with a role (teacher, student or administrator) and corresponding privileges. An initial training procedure was conducted with the researchers as well as with

teachers and students. Features enabled for all participants were: create thematic discussion groups, join existing groups. The groups gave access to discussion forums and blogs and allowed for creating public pages visible within the network.

Sample and Data Collection

The sample consisted of two groups of 40 ninth graders each in a public school in Bogotá (Colombia). One group used the visibility tool and procedures, the other one followed the standard pedagogical practice in this school. The group size in the collected data, however, is usually lower due to frequent absence of a higher numbers of students. To collect data we used field notes, knowledge tests, and data of collaborative work available in the system. Knowledge tests used an open answer format, and a content analysis was conducted to find the concepts the student included. Information on collaborative work was based on answers to the question “with which partners did you work?”, for which the student selected the names from a list with all partner names.

Results

Based on the available interaction data, the UCINET software was used to generate a graphical representation of the social network, i.e. a sociogram. A first visual comparison already identified clear differences in terms of number of relationships between students. The “visibility group” exhibited a higher density of relationships among participants as compared with the control group, for which there were more isolated nodes and less interactions (i.e. edges). Also, for each student we calculated basic structural graph measures such as centrality and degree.

To corroborate the hypothesis that with increasing visibility of the students’ learning products the frequency/intensity of collaborative groups would also increase, we conducted a correlation analysis between the times students spent publishing their results products and their corresponding degree in the sociogram. Results show a significant correlation of $r=0.95$ ($n=22$, $p<0.05$). To prove the hypothesis that with increasing visibility the number of concepts included in knowledge sharing processes would also increase, we conducted a correlation analysis between the student degrees and the corresponding number of concepts assessed through the knowledge test. Results also show a significant relationship ($r=0.85$, $n=20$, $p<0.05$). Finally, the number of concepts included by students from the two groups in the knowledge test was compared using the Student t-test. The difference between means (3.44 and 2.16, respectively) was highly significant ($F = 1.41$, $n=36$, $p < 0.00063$).

Conclusion

Based on our empirical findings, we can state that classroom visibility management stimulates cooperation as well as conceptual development, i.e., in summary, it supports joint knowledge construction processes. Available social networking platforms can be used to set up such environments supporting visibility management, and social network analysis has turned out to be an appropriate tool to visualize and analyze the resulting changes in classroom interactions.

References

- Cocciolo, A., Chae H. S., Natriello G. (2007). Using social network analysis to highlight an emerging online community of practice. Proceedings of the 8th International Conference on Computer Supported Collaborative Learning (CSCL2007), New Brunswick (NJ), June 2007.
- Harrer, A., Zeini, S., Pinkwart, N. (2005). The effects of electronic communication support on presence learning scenarios. Proceedings of the 7th International Conference on Computer Supported Collaborative Learning (CSCL2005), Taipei (Taiwan), June 2005. pp. 190-194.
- Martínez, A., Dimitriadis, Y., Rubia, B., Gómez, E., de la Fuente, P. (2003). Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers & Education*, Vol. 41. pp. 353 – 368
- Stajkovic, A. D., Luthans, F. (2003). Behavioral management and task performance in organizations: Conceptual background, meta-analysis, and test of alternative models. *Personnel Psychology*, Vol. 56 (1). pp. 155-195.
- Vygotsky, L. (1978). *Mind in Society*. Cambridge, MA: Harvard University Press
- Wasserman, S. and Faust, K. (1994). *Social Network Analysis, Methods and Applications*. Cambridge University Press.

Explanatory Activity with a Partner Promotes Children's Learning from Multiple Solution Methods

Miho Kawasaki, Otemon Gakuin University, 2-1-15 Nishiai, 567-8502, Japan, miho.kaw@gmail.com
Hajime Shirouzu, Chukyo University, Japan, shirouzu@sist.chukyo-u.ac.jp

Abstract: This study examined how explanatory activities prepare children to learn from multiple solution methods to mathematics problems. We conducted an experiment involving 124 fifth-grade students using a 2×2 comparison design (Factor 1: *self-explanation* versus *collaborative explanation*; Factor 2: *a formal solution method only* versus *informal and formal methods*). The results showed that the condition under which paired children were presented informal and formal methods and were required to explain why each method would solve the problem was most effective for promoting learning from multiple solutions.

Introduction

To clarify easy and effective ways to introduce CSCL into ordinary classes, we examined whether and how paired student discussions promote their understanding of others' solutions presented to the class. In Japanese mathematics class, students work on a task for the day, present multiple solution methods, and engage in discussion to build a consensus on which method is good and why. In this case, not only formal but also informal methods can be presented. We often observe that the informal methods are incomplete, yet intuitively appealing enough to provoke heated discussion. Yet, it is unclear how to design and foster such heated discussions. For example, whole-class discussion immediately after the presentation of multiple methods is the most popular way. However, this intervention method does not allow students, except for the academically successful children, sufficient time to understand each method, often leading teachers to just state which method is the formal one without discussing its validity. CSCL research tells us that self-explanation (Chi *et al.*, 1994) and collaborative explanation (Miyake *et al.*, 2007) are promising approaches to examining informal and formal methods. Yet, such explanations are often applied to normative worked-out examples, text, or lectures which do not include obscure content. Thus, we do not yet know whether these methods work for other content. Therefore, we conducted a 2×2 comparison, with *self-explanation* versus *explanation in pairs* of two problem-solving approaches, *a formal solution method only* versus *informal and formal methods*, to determine whether explanatory activities promote learning of multiple solutions and how this is achieved.

Methods

The participants were 124 children from four fifth-grade classrooms in Japanese public elementary schools. The subject matter was density as an example of intensive quantities. The participants had received no instruction for comparing intensive quantities prior to the experiment.

Four classes were randomly assigned to one of four intervention conditions. The conditions were varied in terms of the kinds of solution methods presented to the children by video clips and the activities required of them after watching the video clips. Children under the IF-pair condition watched both informal and formal methods with a partner and then explained why each method would solve the problem. Children under the FF-pair condition watched two versions of the formal method with a partner and then explained why each method would solve the problem. Children under the IF-solo and the FF-solo conditions performed the same procedures except they did them alone. With this experimental design, we aimed to replicate in a controlled setting a natural situation in which students present informal and formal solutions and reflect upon them. All children completed the pretest and post-test, which consisted of density-comparison problems, before and after the intervention. For example, the children were asked to compare the density of a flowerbed that had an area of 5 m^2 and 25 flowers with that of a flowerbed that had an area of 7 m^2 and 28 flowers. The problem can be solved by calculating the unit values (the number of flowers per square meter) for the flowerbeds and comparing those values to identify which flowerbed is more dense (unit strategy; Fig. 1a). However, children often use an informal strategy to solve this kind of problem, i.e., they calculate the difference within each dimension and compare these two values (subtraction strategy; Fig. 1b).

All problems were presented in the form of worksheets. The children were asked to decide which flowerbed was denser and to justify their conclusion using algorithmic and/or diagrammatic explanations. In the post-test, children were also required to solve a transfer problem to assess their understanding of equal distribution. In the transfer problem, they were asked to judge whether a worked-out example of a density comparison problem ($7 \text{ flowers} / 3 \text{ m}^2$ vs. $10 \text{ flowers} / 5 \text{ m}^2$) was correct. In the worked-out example, a hypothetical child drew the diagram shown in Fig. 2 and chose the second flowerbed as more dense by comparing the number of flowers in the far left, 1-m^2 area. This is an incorrect answer based on a

misunderstanding of unit strategy. We calculated the number of children who answered that this solution was wrong with an explanation of the need for equal distribution.

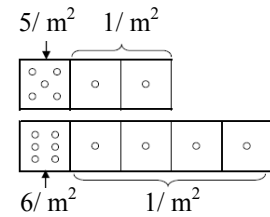
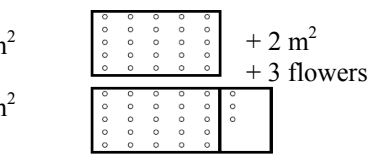
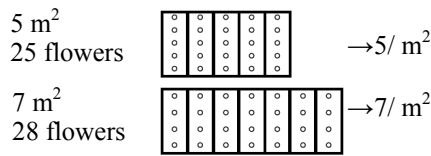


Figure 1a. The Unit Strategy.

Figure 1b. The Subtraction Strategy.

Figure 2. The Transfer Problem.

The procedures were the following. The children were asked to solve one density comparison problem, which they had not learned (pretest). Then, they watched two types of video clips wherein other children explained their solution methods. After watching each clip, the children were given 7 minutes to explain why the methods would solve the problem on a worksheet using the panels presented in Fig. 1 (explanatory activity). Finally, they were asked to solve a similar density comparison problem again and a transfer problem (post-test).

Results and Discussion

First, results on the post-test showed that IF-pair group provided justification for the formal method at a higher rate than did children under the FF-solo condition ($\chi^2(6) = 20.4, p < .01$). As shown in Fig. 3, FF-solo group applied the unit strategy formula without explaining it (white-colored portion), whereas children under other conditions applied this strategy and accompanied it with an explanation of its meaning (black-colored portion). The conditions that fostered such explanation included at least either the presentation of multiple solutions or collaborative explanatory activities, the former of which enriched variety in solution types and the latter of which fostered alternative viewpoints on solutions. Furthermore, results on the transfer problem showed that IF-pair group rejected the incorrect solution method and detected the deficit in that method at a significantly higher rate of 30.8% than the other groups ($\chi^2(3) = 8.15, p < .05$; FF-pair: 4.4%, IF-solo: 12.9%, FF-solo: 9.7%). Thus, both experiencing and discussing multiple methods with a partner was necessary for improved performance on the transfer task. The overall results indicated that a collaborative discussion of multiple solutions increased the conceptual understanding of the unit strategy. Finally, we examined the conversation of the IF-pairs as they were explaining the formal method. We found that, when at least one member of the pair completed the transfer problem correctly, they were more likely to refer to equal distribution than were the other pairs in their conversations ($t(8) = 1.94, p < .05$). This result suggests that they interpreted the subtraction strategy based on the principle “the more space there is available, the less dense it is” and applied this principle to explaining the unit strategy. Thus, they understood that the difference in the space per 1 m² was consistent across all 1-m² units.

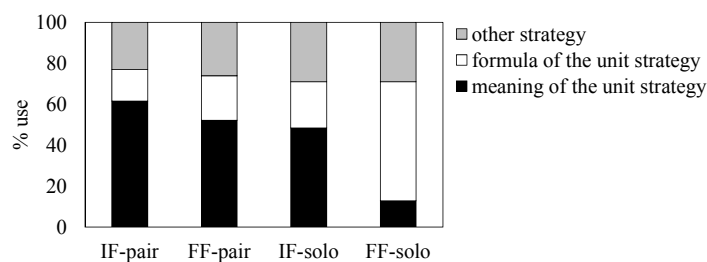


Figure 3. Percentage of Children Who Applied Each Strategy by Condition.

These findings imply that constructing explanations collaboratively requires that children make others’ informal method comprehensible and coherent by seeking some rationale, that they make sense of the formal method in the light of that rationale to differentiate the core unit of the solution procedure from its irrelevant units, and that they appreciate the essence of the formal method. Although it may be unusual to ask children to explain both informal and formal methods presented by others, such an opportunity could help them develop their own understanding while distinguishing the components of each method. This might be an important process of learning from multiple solution methods. Yet, this result might be due to our deliberate selection of the “informal method.” Much work needs to be done to increase the generalizability of the results.

References

Chi, M. T. H., Leeuw, N., Chiu, M. H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, 18, 439-477.

Miyake, N., Shiga, K., & Shirouzu, H. (2007). Developing question asking skills through collaboration. *Proceedings of the 29th meeting of the Cognitive Science Society (CogSci2007)*, USA, 14.

Collaborative Design Process of a Rich Interactive Web-based Interprofessional Pain Education Resource

Michelle Lui, Judy Watt-Watson, Leila Lax, Adam Dubrowski, Michael McGillion, Judith Hunter, Kerry Knickle, Cameron MacLennan, Anja Robb, Jaime Lapeyre,
University of Toronto, University of Toronto, 252 Bloor Street West Toronto, Canada, ON,
Email: michelle.lui@utoronto.ca, j.watt.watson@utoronto.ca, l.lax@utoronto.ca, adam.dubrowski@utoronto.ca,
michael.mcgillion@utoronto.ca, judith.hunter@utoronto.ca, kerry.knickle@utoronto.ca,
cameron.maclennan@utoronto.ca, anja.robb@utoronto.ca, jaime.lapeyre@utoronto.ca

Abstract: This paper describes the design process of a Web-based interprofessional pain education resource for pre-licensure health sciences students. Working in a large multidisciplinary team, an authentic patient case was constructed. Situated in interprofessional complex care, the case highlights learning objectives related to pre- and post-operative care and treatment up to one-year for a surgical cancer patient. Collaborative design maps, copy decks and other strategies to support our collaborative design process are discussed.

Introduction

Design processes are increasingly collaborative - especially when complex interactive projects are the proposed outcomes. From the Human Computer Interaction field, user-centered design is commonly viewed as the *de facto* design approach. As a broad design philosophy, encompassing a variety of methods, user-centered design generally describes any design processes where end-users influence the overall design (Abrams, Maloney-Krichmar, & Preece, 2004). Participatory design is considered a subset of user-centered design and refers to a process where the users are actively involved in the development of the products. In the learning sciences, we use the term 'co-design' to refer to projects where the classroom teacher has an integral role of the design process. Used for developing innovations that fit into authentic classroom contexts, this process relies on teachers' ongoing involvement to design educational innovations (Penuel, Roschelle, Shechtman, 2007).

All of the approaches described above reflect a way to design with multiples voices in the process, which sit in contrast to traditional co-operative processes in design studios where each member of the team possesses a distinct role. For example, the creative director would decide on the vision and strategy for the project, the graphic designer would be responsible for the layouts, logo and interface design, and the programmer would add interactive functionality based on a final design document. In many academic teams, however, members tend to take on more amorphous roles. A direct result of this is a more open and collaborative environment. Although each member arrives with expertise in specific areas, their voices are valued (and often expected) in other parts of the project. However, when working in a large multidisciplinary team, members not only provide much needed content and technical expertise, they also come with their own set of background, perspectives, biases and disciplinary jargon. This can be demonstrated by the collaborative design process in creating an interprofessional pain education resource (IPER) for pharmacy, nursing, medicine, occupational therapy, physical therapy, and dentistry students. This paper presents the IPER and strategies used to achieve a common conceptual space to effectively design the resource.

Interprofessional Pain Education Resource

An authentic patient case was constructed relating to the interprofessional complex care of a surgical cancer patient to highlight pain learning objectives related to pre-operative, post-operative, and treatment up to one-year (Figure 1). Video vignettes were created not only to carry the case narrative, but also to simulate real-world authenticity within the learning environment.

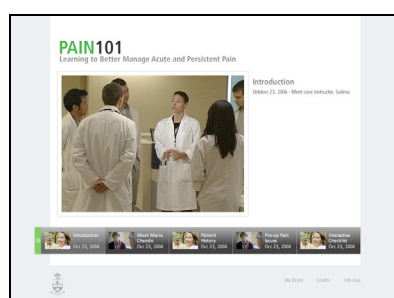


Figure 1. A Sample Screen of the IPER.



Figure 2. Pain Beliefs/Misbeliefs Checklist.

In the development of the IPER improvement of pain knowledge and correction of misbeliefs was identified as the main educational goal. Educational objectives around pain mechanisms, assessment and management and initial content scripts were considered alongside educational theories to support pedagogic design. Interactivity and video commentaries were designed around learning objectives. For example, in the pre-operative section of the IPER, an interactive, pain beliefs/misbeliefs checklist was created (Figure 2). Students would read the list of statements and check “true” or “false” box for each statement. Whether students answered correctly or incorrectly, responses would be indicated and concurrent, explanatory feedback provided. An illustrative video commentary would be immediately displayed to highlight the misbelief in a typical health care scenario and how this in turn results in poor practice. A voice-over explanatory commentary then explicitly address the pain misbelief, the relationship to care, and clarifies best practice.

Collaborative Design

Our design team consisted of experts from a variety of disciplines, including nursing, physiotherapy, education, videography, and design and Web-development. This necessitated the establishment of a common language in our discussions concerning the resource. Another consideration was the complexity of the design and the need to organize emerging ideas. The goal was to create a rich, highly interactive educational resource that incorporated a number of different media (e.g., video, animation, interactivity, slides). In order to facilitate our collaborative discourse, we developed a design map to represent the content scripts, interactivity and application flow of the resource (see Figures 3, 4).

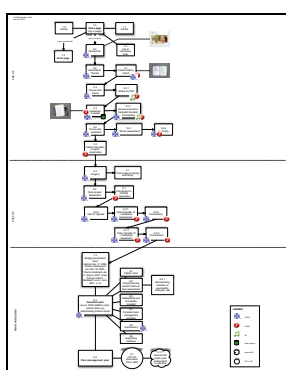


Figure 3. Collaborative Design Map.

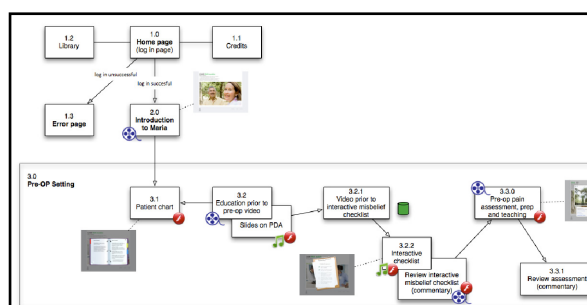


Figure 4. Close-up of Pre-operative Section in the Design Map.

Drawing from Web conventions in flowcharting sitemaps (Iuppa, 2001) and film and animation storyboarding (Tumminello, 2005), our design map allowed ideas to be visualized, added, deleted and shifted during our ideation process. Each box in the map represents a unit of content (i.e., sections and subsections) and lines between the boxes represent how content is linked throughout the application. We used symbols to identify the type of content in each box (e.g., blue film wheel representing video, green music note for voiceovers, and a Flash icon representing interactive content). Designed screenshots served to quickly describe the content with relatively little screen real estate. While nodes and links convey high-level overview information as well as relationships between elements, for documenting detailed content information we incorporated a numbering system in the maps. Numbers in the maps correspond to those in a text file, known as a copy deck. Typically, there are two columns in a copy deck, delineating audio content and visual content. The beginning of a section is marked by the number and title of the section followed by the appropriate content. For example, in one of the sections, the narration script for video content is on the left and the description of the hospital scene is on the right. The combination of copy deck along with the design map allowed the team members to discuss everything from broad application flow to interactivity and detailed content scripts in the IPER, and provided the team with a shared artifact and common language for continued development.

References

- Abras, C., Maloney-Krichmar, D., Preece, J. (2004). User-Centered Design. In Bainbridge, W. *Encyclopedia of Human-Computer Interaction*. Thousand Oaks: Sage Publications.
- Iuppa, N. (2001). *Interactive Design for New Media and the Web*. Boston: Focal Press.
- Penuel, W.R., Roschelle, J. & Shechtman, N. (2007). Designing formative assessment software with teachers: An analysis of the co-design process. *Research and Practice in Technology Enhanced Learning*, 2(1), 51-74.
- Tumminello, W. (2005). *Exploring Storyboarding*. New York: Thomson Delmar Learning.

Acknowledgments

We gratefully acknowledge funding of this initiative by *CIHR/Community Alliances for Health Research and Knowledge Translation on Pain grant #86786*.

Talking Like a Composer: Negotiating Shared Musical Compositions Using Impromptu

Michael P. Downton, Kylie A. Peppler, Indiana University 107 S. Indiana Ave. Bloomington, IN. 47405
Email: mdownton@indiana.edu, kpeppler@indiana.edu

Jeanne Bamberger, University of California-Berkeley, 230 Morrison, Berkeley, CA. 94720, jbamb@mit.edu

Abstract: Research in CSCL has largely focused on mathematics and science while little research to date has focused on the arts and particularly music. However, very little is known about how tools to support shared musical performance and composition might foster heightened musical understanding. The current study focuses youth engaged in a collaborative remixing of Beethoven's *Ode To Joy*. Early findings suggest that, through collaboration, meaningful discourse around structures and logic in music composition takes place.

Introduction

Research in CSCL has largely focused largely on mathematics, science and to some extent language arts, while little research to date has focused on the arts and particularly music. As way of illustration, a search for the term 'music' in the *International Journal of Computer-Supported Collaborative Learning* (IJCSCL) database yielded only eight results (IJCSCL, 2010); most of which described the sharing of music as an activity that users engaged in while none dealt specifically with the discipline of music as a collaborative activity. However, what was once a seemingly complex, predominantly passive, and individualized digital activity (i.e., the listening to music) is now developing into a highly collaborative, and creative endeavor facilitated by the advent of new computer programs that facilitate composing and sharing of music in new ways, which has largely been ignored by researchers and educators (c.f., Salavuo, 2006). People, especially youth, are no longer 'passively' listening to music, but actively engaging in it through several pathways: Video games like *Guitar Hero* and *Rock Band*, for example, are changing the listening experience to an active, engaging, and musical one (Miller, 2009; Authors, Lindsay, and Hay, under review) in which players report they listen more deeply to the structure of the song than they had in previous hearings. Computer programs, like *Impromptu* (Bamberger, 2000) and *Garageband*, have also changed the listening experience and the lines between composer and listener have since become blurred. This is now an apt time to investigate how the computer aides in fostering and developing discourse about music both in- and out-of-the-classroom. Using a constructionist approach to learning and development, the current study sought to better understand how to support disciplinary learning in music through computer-supported collaborative discourse. More specifically, our study sought to answer the following questions: Do youths' conversations reflect a deep understanding of the complexities of music composition? Are the content of these conversations reflected in their own music compositions?

Research Approach

The project took place from January to May of 2010 in a mid-sized Midwestern elementary fifth-grade classroom within a college community. The classroom consisted of 22 (12 girls and 10 boys) middle to upper middle-class youth with mixed ethnic and religious backgrounds. To facilitate the activities, researchers utilized the computer program *Impromptu* that allows users to engage with the structural functions of music—music from its meaningful chunks—rather than at the singular note level (Bamberger, 2000). A specific feature, not found in any commercial type music making software, is the importance of documenting the users decisions and why they were made; essentially getting at the notion of 'what happens if...' From the beginning, youth were asked to document their decisions while reconstructing and remixing tunes. However, early investigation into the youth documents revealed their writings were process-based, which was not useful in understanding how youth engage with music and composition. To help youth understand the importance of writing the reasons of *why* they did what they did, researchers set up a class discussion around remixing the popular tune *Ode to Joy* by Ludwig van Beethoven. The researcher acted as both the investigator and discussion facilitator. The resulting videotaped classroom discussions were transcribed and further analyzed utilizing an exploratory and thematic analysis for this proposal.

Theoretical Framework

Music, at its core, is a constructive and creative activity and the theoretical framing of Constructionism ties in closely with music. Constructionism is a framework that builds off the Piagetian notion of constructivism and adds that learning happens best when learners are actively engaged in making a shared, external artifact, which in this case is both the collaborative conversation as well as the music composition (Papert, 1980; Kafai, 2006). Moreover, there are many interesting tools, like *Impromptu*, that have been developed with a Constructionist frame of learning to foster deep learning from the purposeful design of new artifacts.

Findings

The initial plan was to have a simple 10 to 15 minute discussion, however, the discussion lasted almost an hour with deep, collaborative, and well-mannered conversations in which complex musical functions and concepts were emerging through their discourse. This finding suggested to us that collaborative methods for composition aided by the computer are productive learning spaces, which stands in stark contrast to the methods in which composition is usually taught in academia as a solitary, isolated activity.

Second, findings suggest that youth while collaboratively constructing a new tune from familiar musical ‘chunks’, think and speak deeply about musical concepts that were thought to only reside in the trained professional. The first highlights the collaborative discourse about specific structural changes to the song. Specifically, the students are discussing how the song would sound with the tempo sped up considerably from 130 beats per minute (bpm) to 230 bpm.

Researcher: Because if we change the tempo it is gonna change...

Sammy: Yeah, it is gonna change all the tune blocks

Researcher: Yeah its gonna change the entire...

Keith: I know, but that would be cool.

Researcher: Well let’s try it and see what it sounds like.

Gary: Not until were done.

Sean: I want to do it now.

Foster: Wait, wait before we think about what are we at right now so if we don’t like it we can come back to it.

This exchange demonstrates that it is possible for the whole class to negotiate and think through structural changes of the song in a productive manner. Furthermore, it gets the students to think more deeply on how the tempo changes the song, which is a difficult concept to get at just by listening, which is demonstrated in the following reflection made by Pia:

Pia: Well, I don’t really like it going this fast because you can’t really enjoy the song, I mean I like it fast, but I don’t like it this fast...it’s sort of just a monotone of just notes

This passage highlights how Pia is thinking about how the tempo of the song affects the overall outcome of certain passages in the song. Her mentioning that “...a monotone of notes” implies that the listener would not be able to hear and appreciate all the notes that are being played because of the tempo being as fast as it is. It is dilemmas such as these that professional composers think about when engaging with a piece of music. However, what the professional composer does not have is collaborative feedback on his or her decisions.

Implications

Music as a discipline is an under researched area in the field of computer-supported collaborative learning. What this research shows is that youth think about music much in the same way that professional musicians do just using different language to get at their meanings and through their discussions they acquire new domain specific language to use (e.g., tempo). The computer and other hardware devices are tools that can mediate this type of discourse. This research also highlights that certain musical functions serve a purpose (e.g., slower tempo allows for deeper listening) much like the “+” sign in math serves a purpose. Youth, in their collaborative discussions, recognize these functions and discuss their purpose on a much deeper level than just ‘finding an answer’. Further research will be conducted to investigate how youth engage with both synchronous and asynchronous music learning spaces and how these spaces support learning.

References

- Authors, Lindsay E. C., and Hay, K. (under review). The Nirvana Effect: Tapping video games to mediate music learning and interest. *The International Journal of Learning and Media*
- Bamberger, J. (2000). *Developing musical intuitions: A project based introduction to making and understanding music*. New York, NY: Oxford University Press.
- International Journal of Computer-Supported Collaborative Learning. (2010). Accessed October 17, 2010 from <http://www.springerlink.com/content/1556-1607/?k=Music>
- Kafai, Y. (2006). Constructionism. In R. K. Sawyer (Ed.) *The Cambridge Handbook of the Learning Sciences* (pp. 35-46). Cambridge, MA: Cambridge University Press.
- Miller, K. (2009) Schizophrenic performance: *Guitar Hero, Rock Band*, and virtual virtuosity. *Journal of the Society for American Music*, 4, 395-429.
- Salavuo, M. (2006). Open and informal online communities as forums of collaborative musical activities and learning. *British Journal of Music Education*, 253-271.

Agreeing to Disagree: Challenges with Ambiguity in Visual Evidence

Camillia Matuk, Elissa Sato, Marcia Linn, University of California, 4523 Tolman Hall, Berkeley, CA #1670, 94720

Email: cmatuk@berkeley.edu, elissa.sato@gmail.com, mclinn@berkeley.edu

Abstract: Students in CSCL environments can exhibit sophisticated argumentation skills. However, the challenges of using visual evidence are rarely addressed by current technological scaffolds. In light of the issues demonstrated in a dispute between two students over the meaning of a graph, we recommend that CSCL systems not only capture the outcomes of argumentation, but also the processes, whether of agreement or dissent. These would provide valuable learning objects, as well as insights into students' learning.

Background and Objectives

Learner-paced CSCL activities can allow students to pursue ideas through extended debate – opportunities for which are rare in traditional classroom instruction (Radinsky, Oliva, & Alamar, 2010). Technology-based scaffolds can furthermore enhance the benefits of learning through argumentation (e.g., Chin & Osborne, 2010) by supporting the interpretation and use of evidence in important discursive patterns, such as challenging, justifying, explaining, and understanding various perspectives of these processes. However, existing scaffolds rarely account for the unique challenges of using visual evidence in argumentation. Here, we offer an empirical illustration of the challenges posed by visual evidence, and recommend design features for CSCL environments that would support its use in students' argumentation.

Data Sources and Methods of Analysis

Our participants are Ted and Keiran (pseudonyms), one of 55 pairs of students in a California middle school who completed Global Climate Change (GCC). In GCC, a 5-day long computer-based module developed in the Web-based Inquiry Science Environment (WISE). In GCC, students are guided in their explorations of graphs and simulations to investigate the interaction of solar radiation with the earth's surface and atmosphere, and the impacts of human activity on levels of greenhouse gases. We focus on a dispute between Ted and Keiran that occurred on the first day of GCC, in which they attempt to resolve conflicting interpretations of a graph of global temperature change (Figure 1). Their case was selected because it illustrates the variety of argumentative strategies students can exhibit in CSCL systems. We qualitatively describe some unique challenges of using visual evidence in argumentation, and conclude by discussing implications for the design of CSCL environments that would support productive discourse with visual evidence.

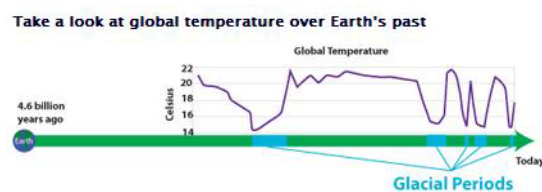


Figure 1. The Graph under Dispute by Ted and Keiran.

Findings

Perceptions are strongly influenced by prior expectations. Although the issue of subjectivity is true of any mode, there is an inherent vagueness of visual as opposed to numeric evidence (e.g., consider how 7 is indisputably greater than 2, but the visual salience of shape and line is subjective) that makes perception alone especially influenced by individual prior knowledge and expectations. For instance, Ted correctly recognized the rising and falling curve as an indication of fluctuating global temperatures: Sometimes it was hotter, and sometimes cooler than today. Meanwhile, Keiran attended exclusively to the pattern of increasingly narrow blue bars along the x-axis. These, he maintained, denoted briefer ice ages toward the present, and thus confirmed an assertion he had filtered from the previous activities in the unit, that “global warming made it warmer.” It was a catchphrase he had earlier repeated, which now influenced the relative salience of the graphic elements before him.

Subjective interpretations are difficult to refute. Both Ted and Keiran skillfully provided evidence to justify their claims: Keiran directed Ted to notice the pattern of blue bars as consistent with increasingly shorter ice ages, as they had learned in the previous activities; and Ted broke down for Keiran the manners by which

different locations on the temperature curve corresponded to different temperature fluctuations. Yet, neither could find definitive fault in the logic of the others' interpretation. With no definitive way to interpret the graph, the students could only emphasize those components they personally deemed most salient. When Ted suggested Keiran mistakenly overlooked the temperature curve, Keiran objected, saying he did in fact consider it, but consciously disregarded it. "The thing that supported my answer was this," he said, and indicated the green x-axis. Such is the subjectivity of visual evidence that making explicit links between evidence and claims was alone not persuasive enough to shake either Ted or Keiran's commitments to their individual perceptions.

Criteria for evaluating visual evidence are not apparent. Failing to make Ted's perceptions align with his own, Keiran sought evidence beyond the graph as justification for his claims. In one instance, he argued that if the temperature curve were as important as Ted believed, the curriculum designer would have featured it accompanied by an explanation in the previous introductory screen. However, as the activity sequence was designed, only the green axis is presented with such an introduction. "That's the only important thing," Keiran consequently asserted. "That's why they only put this." In another instance, Keiran extrapolated a pattern from the temperature curve to support his claim that global temperatures were increasing. "It was super hot here," he said, and indicated a high point on the curve, "So I think it's going to be even hotter here," and he moved the cursor beyond the very end of the curve. That Keiran inappropriately resorted to making such inferences from evidence that was not available highlights the general lack of clear criteria upon which students can draw to effectively evaluate visual evidence.

Conclusions and Implications

Many CSCL environments assume eventual consensus between partners. Yet, supporting meaningful engagement in science means not only attending to the products of students' investigations – their consensus explanations – but also to the argumentative processes of their construction (Berland & Reiser, 2009). Indeed, in striving to reach consensus over conflicting views, students are stimulated to challenge one another's ideas and to make sense of alternative perspectives. By articulating connections between evidence and their claims, they can come to recognize where their knowledge lacks, and to build shared understanding of the phenomena investigated. However, such processes are rarely captured and objectified in CSCL systems. Moreover, with fewer criteria for evaluating visual as opposed to numeric data, it can be difficult for partners to successfully argue for and refute conflicting interpretations. As a result, students can be left struggling to effectively use visual evidence in argumentation. And with only one field in which to type what is meant to be a mutually agreed upon response, one of the partners will eventually feel the need to relent. "Just do it your way. I don't care if we got it right," Kieran told Ted. "But write 'I'," he insisted, seeking to distinguish Ted's response from his own.

To address these issues, CSCL systems might maintain a tangible record of key events and relations made between components of students' arguments, but with particular attention to the challenges of interpreting and using visual evidence. Thus, systems might prompt students to not only be explicit about the evidence they select from a given artifact as the basis of their claims (e.g., a fluctuating curve or a pattern of colored bars); but to also identify and articulate the prior knowledge and expectations attributed to their selections. Doing so may encourage greater awareness in students of the influences on their perceptions, and can also facilitate critical evaluation of visual evidence. Moreover, it would provide an artifact with which teachers and researchers can understand and assess students' use of and learning with visual evidence.

References

- Berland, L. K. & B. J. Reiser (2009). Making sense of argumentation and explanation. *Science Education*, 93(1), 26-55.
- Chin, C., & Osborne, J. (2010). Students' questions and discursive interaction: Their impact on argumentation during collaborative group discussions in science. *Journal of Research in Science Teaching*, 47(7), 883-908.
- Radinsky, J., Oliva, S., & Alamar, K. (2010). Camila, the earth, and the sun: Constructing an idea as shared intellectual property. *Journal of Research in Science Teaching*, 47(6), 619-642. doi: 10.1002/tea.20354

Facilitating Knowledge Communities in Science Classrooms through Scripted Collaboration

Hedieh Najafi, Naxin Zhao, James Slotta, University of Toronto, 252 Bloor St. W., Toronto, ON, Canada
Email: Hedieh.najafi@utoronto.ca, naxin.zhao@utoronto.ca, jslotta@oise.utoronto.ca

Abstract: In two iterations of a design-based research we studied knowledge communities in secondary school science classrooms following the Knowledge Community and Inquiry model. We co-designed a Climate Change unit enriched with pedagogical and technological scaffolds to support collaborative inquiry. We examined the emergence of collective cognitive responsibility, knowledge co-construction processes, and students' depth of understanding of climate change science. Scaffolds were redesigned for iteration2 based on findings from Iteration1.

Introduction

This study attends to the problem of developing inquiry-oriented knowledge communities in secondary school science classrooms. Using the Knowledge Community and Inquiry model (Slotta & Peters, 2008) to guide curriculum design for a grade-10 Climate Change curriculum unit, we investigated the success of the model and proposed areas of improvement for upcoming studies. We use a design-based approach (DBRC, 2003). We conducted this study in two design iterations in 2008-2009 and 2009-2010 school-year in grade 9 classes of a high school in Toronto, Canada. The co-design team consisted of 3 researchers and a science teacher. Here, we share the co-designed curriculum for Iteration 1 and Iteration 2 of this study, emphasizing pedagogical and technological scaffolds designed to foster collaborative knowledge construction.

Design Iteration 1

Technology Platform

Wiki seemed an appropriate technology to be used. History function in wikis allows for tracking students contributions to their shared pages in terms of frequency and quality. A drawback of wikis, at the time of writing this dissertation, is that they do not allow more than one person to edit a page at a time.

Curriculum Co-design

Participants in Iteration1 were 42 students in 2 sections of a science class. Co-designed curriculum had 3 phases.

Phase 1: Establishing a knowledge community. This phase introduced the students to a knowledge community culture: Understanding the importance of collaboration and sharing in a public knowledge space. A central scaffold in this phase was an "Introduction to Knowledge Community" lecture to discuss the philosophy of science and the importance of becoming able to function in a knowledge society.

Phase 2: Collaborative inquiry project focused on identified issues. Phase 2 consisted of a whole class brainstorm and a small group collaborative inquiry project. The objective was for the students to co-construct a shared knowledge base to be used in a subsequent inquiry project. Scaffolds designed for this phase were:

- Brainstorm to identify important climate change issues. In a wiki page students from both sections added a climate change issue that they deemed important and asked an inquiry question about it.
- Collaborative inquiry to co-construct knowledge. The Regional Groups inquiry activity examined climate change issues in seven regions of Canada. The teacher divided the students from both sections in seven groups. We designed a template that scripted the content of the inquiry.

Phase 3: Utilizing co-constructed knowledge base. In phase 3 students were supposed to use their collective knowledge to determine how climate change would impact the work or agenda of specialists and to devise strategies to alleviate adverse effects of climate change in Canada. The main scaffold was a Collaborative inquiry to use shared knowledge. Upon completion of the Regional Group activity, six specialist groups were formed across two class sections and collaborated for three sessions using a wiki template.

Implications for Design Iteration 2

Based on formative analysis, we proposed three design guidelines for Iteration 2: A new scaffold for the collaborative inquiry to emphasize science connections; A planning page for groups to use during collaborative inquiry projects; Embedded reflections to raise students' awareness.

Design Iteration 2

Technology Platform

In the summer of 2009, the co-design team saw the incapability of the existing wiki platform to support a collaborative curriculum. An alternative platform that ran on Drupal 6 was thus developed.

Curriculum Co-design

3 teachers implemented the redesigned Climate Change curriculum in 5 class sections. A three-phase curriculum, corresponding to three phases of the KCI model, was designed.

Phase 1: Establishing a knowledge community in climate change science. To introduce the students to the knowledge community culture (e.g. understanding the importance of collaboration and sharing knowledge in a public space) the following scaffolds were designed:

- Climate change issues brainstorm. Each class section started their brainstorm using ideas from previous classes as starting point. The goal was to synthesize students' ideas of climate change issues into a series of topics for an upcoming collaborative inquiry activity. By the end of this activity, students categorized their ideas and entered in the Brainstorm section of the Drupal site.
- Introduction to knowledge communities. The researchers talked to students about the concept of knowledge community. We emphasized that the highlight of the collaborative work would be to learn more by building on existing ideas.

Phase 2: Knowledge co-construction. Phase 2 consisted of a six-week collaborative inquiry project, five individual reflections, and a peer review activity. Collaboration scripts included:

- Climate issues in Canada: Collaborative inquiry. In a collaborative inquiry project small groups chose a climate change issue and examined it from several scientific and social perspectives. The purpose of this collaborative inquiry activity was to co-construct the core knowledge base of classroom community. The Climate Change Issues inquiry project. Informed by findings from Iteration 1, a more explicit scaffold was used for this inquiry. A multi-section page was implemented in Drupal for each Climate Change Issue that consisted of sections with embedded hints and/or sentence openers that sought explanatory responses (Hakkarainen, 2003). For this inquiry project, teachers in each of the five sections introduced the Climate Change Issues inquiry project and emphasized that 2 groups of students from 2 different sections would collaborate to conduct inquiry on a selected issue.
- Group planning pages. To reinforce students' awareness, a planning page was included where students could identify their goals, plan to accomplish them, and monitor the progress of collaborative inquiry.
- Individual reflections. 6 individual reflections were added to the Issues inquiry activity. Items addressed in reflections fell into two categories: Content knowledge, and metacognitive knowledge.
- Peer review. Small groups of students would have developed a comprehensive knowledge of their own issue but would lack awareness of the shared knowledge in other groups. Theoretical frameworks of knowledge communities, propose collective ownership towards shared knowledge. A peer review activity was designed for students to review knowledge shared in other groups.

Phase 3: Utilizing co-constructed knowledge base. In phase 3, curricular activities changed gears from knowledge co-construction to knowledge reuse and improvement. Phase 3 consisted of a small group inquiry activity to examine strengths and shortcomings of remediation plans, identified in phase 2, and to suggest improvements or propose a new plan. This phase consisted of one collaboration script.

- Collaborative inquiry to improve remediation plans. Previously, students had identified several remediation plans, which became the theme for phase 3 of curriculum. This inquiry activity was bound to single sections of classes. Students examined the effectiveness of selected remediation plan on relevant issues, suggested improvements to the plan, and predicted the implications of the modified plan in the future. Each group had a Drupal page with a built-in scaffold. Technological scaffold for remediation pages simulated simultaneous edits. Every remediation page was implemented as a collection of individually editable subpages concatenated in one page. Upon opening a remediation page, each student in the same group could edit one of the sections of the page independently.

Concluding Notes

Analysis of data collected in this research showed significant content knowledge gain from pre to post tests. We are currently in the process of analyzing collaboration patterns and group's collective knowledge advancement in Iteration 2 to detect any improvement over individualistic/split-group knowledge co-construction in Iteration 1.

References

- Design-Based Research Collective (BDRC) (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8.
- Hakkarainen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching*, 40(10), 1072-1088.
- Slotta, J. D., & Peters, V. (2008). A blended model for knowledge communities: Embedding scaffolded inquiry. *Proceedings of the International Conference of the Learning Sciences*. Utrecht.

Ways of Contributing to a Knowledge-Building Dialogue in History

Resendes, M., Chuy, M., Chen, B., Scardamalia, M., Institute for Knowledge Innovation and Technology, OISE/University of Toronto, 252 Bloor Street West, Toronto, ON, Canada
 Email: monica.resendes@utoronto.ca, maria.chuy@utoronto.ca, bodong.chen@utoronto.ca, marlene.scardamalia@utoronto.ca

Abstract: This study explores grade four students' ways of contributing to knowledge building in history. Quantitative and qualitative analyses cover three months of online dialogue in Knowledge Forum. Preliminary results indicate that students were actively "building contexts," "theorizing" and "using substantive concepts"; the more they theorized, the more they asked questions, provided contextual details, and engaged historical concepts. "Introducing new facts" facilitated idea improvement. Outcomes will inform the design of scaffolds to support high-level historical discourse.

Introduction

Given that new knowledge is advanced in large part through the discourse of knowledge creating communities, this study explores student ability to contribute to explanation-seeking dialogue in history. The concept of "explanatory coherence" (Thagard, 1989), serves as both an objective and a basis for evaluating the historical explanations students construct. Thus, the main objective of this study is to begin to explore how different ways of contributing to collaborative knowledge building discourse can help students improve their ability to exercise high-level historical reasoning through the creation of coherent historical explanations. This study explores Knowledge Building (Scardamalia & Bereiter, 2003) for historical inquiry, a pedagogical approach defined as "*the production and continual improvement of knowledge of value to a community*" (Scardamalia & Bereiter, 2003: p. 1370). The pedagogy is supported by Knowledge Forum (Scardamalia, 2004), a shared knowledge space in which students contribute ideas, questions, and so on, to multimedia *notes* positioned on graphical *views*, which serve as organizing backgrounds. Verbal *scaffolds* embedded in notes support specific discourse moves. For this work students used a scaffold that encouraged them to state and improve their theories.

Method

Participants and Dataset

Participants for this study included 21 Grade 4 students (9-10 years) attending a primary school in downtown Toronto, and their teacher. The class engaged in Knowledge Building three times a week for 45-60 minute periods that included "KB [Knowledge Building] talks" coupled with time on Knowledge Forum. The dataset is comprised of three months of online dialogue about medieval history totaling 545 notes across 13 views.

Plan of Analysis

General Distribution of Contributor Roles

In order to delineate contribution types, individual notes were coded according to a discourse schema with nine main categories and 30 subcategories. Six categories were adapted from Van Drie and Van Boxtel's (2008) framework for historical reasoning, including—I.) Asking historical questions (factual and explanatory) II.) Building historical contexts (social, spatial, temporal) III.) Using substantive concepts (inclusive, unique, colligatory) IV.) Using meta-concepts (historical significance, historical perspective, historical empathy, change and continuity, cause and consequence) V.) Argumentation (weighing claims, making counter-claims, accounting for counter-claims) VI.) Using historical sources (introducing a fact, using sources to support/reject an idea, seeking, comparing or evaluating sources). Because Knowledge Building focuses on collaborative theory building, we added three categories adopted from a coding schema the authors developed for a similar study in science (see Chuy, Resendes & Scardamalia, 2010). These include—I.) Theorizing (proposing, supporting, improving, seeking alternatives) II.) Synthesizing and comparing (synthesizing ideas, "rising-above", making comparisons) III.) Supporting discussion (giving opinions, mediating). The most complex view comprised 18% of the total notes and was analyzed independently by two raters with 80% agreement. The 20% disparity was resolved through discussion. The remaining 12 views were coded by the primary author.

Case Analyses of Theory Development

For case analyses, we selected contributions pertaining to "theorizing"—namely, "improving explanations"—to examine their role in theory development. All contributions were traced from notes that were components of "inquiry threads" (see, Zhang, Scardamalia, Lamon, Messina & Reeve, 2007) where the move from half-baked

theories to more coherent explanations was evident. Case analysis focused on two questions—I.) What is the nature of the knowledge advance? II.) Did certain contribution types help raise the level of discourse?

Preliminary Results

General Distribution: What Types of Contributions Are Evident in the Discourse?

Preliminary analysis shows that students engaged most frequently in “building contexts” (28.11%), “theorizing” (15.87%) and “using substantive concepts” (15.67%), showing that young students are interested in building historical contexts and proposing historical theories, and are capable of using a high number of substantive concepts to this end. Students also engaged in “asking historical questions” (11.15%) and “using historical sources” (11.56%), indicating that they are able to pose multiple questions and utilize authoritative sources in their theorizing work. The least frequent modes of contribution were “supporting discussion” (5.27%), engaging meta-concepts (8.13%), argumentation (2.39%) and “synthesizing and comparing” (1.85%). Further research is needed to determine whether boosting these less frequent modes would raise the level of historical reasoning.

Do Relationships Exist Between Students’ Theorizing and Other Contribution Types?

A Spearman correlation analysis was conducted to examine whether there is a relationship between students’ theorizing and other contribution types. Results suggest a positive relationship between “theorizing” and “asking historical questions” ($r = .58^{**}$); “building historical contexts” ($r = .83^{***}$); “using substantive concepts” ($r = .62^{**}$); and “engaging meta-concepts” ($r = .65^{**}$). Thus, it appears that the more questions students asked, and the more they worked to build historical contexts, the more theorizing students performed, including generating different theories, supporting or rejecting theories based on gathered information, and improving theories. Results also suggest that the more students theorized, the more they engaged “meta” and substantive concepts.

Case Analyses: What Role Do Contribution Types Play in Knowledge Advancement?

Case analysis of inquiry threads was conducted to complement quantitative findings. Improved explanations revealed a deeper understanding of *particular* historical contexts that relied upon constructive use of authoritative information. Students also engaged issues of historical causation in increasingly complex ways, such as moving from theories that explain historical action in terms of personal desires or “generalized stereotypes” to those that begin to employ “situational analysis” (see Lee and Ashby, 1997). In three cases, the “introduction of a new fact” embedded within a collective inquiry was the catalyst for idea improvement.

Can We Advance Historical Reasoning through Design Experimentation?

More research is needed to determine whether these results form the basis of more general discourse patterns and the extent to which they apply to all participants rather than conveying results on average, with substantial variation across participants. Current work aims to advance discursive moves such as “using historical sources” and “synthesizing knowledge.” Since “using historical sources” is critical to high-level historical work and is important for students’ theory improvement, new scaffolds will directly target this competency. Also, new scaffolds will be designed to make the value of meta-concepts more explicit. We aim to extend the repertoire of contribution types and demonstrate more consistent change to more advanced concepts by more students.

References

- Chuy, M., Resendes, M., & Scardamalia, M. (2010, August). *Ways of contributing to knowledge building dialogue in science*. Paper presented at the Knowledge Building Summer Institute, Toronto, Canada.
- Lee, P., Dickinson, A., & Ashby, R. (1997). “Just another emperor”: Understanding action in the past. *International Journal of Educational Research*, 27, 233–244.
- Scardamalia, M. (2004). CSILE/Knowledge Forum. In *Education and technology: An encyclopedia* (pp.183-192). Santa Barbara: ABC-CLIO.
- Scardamalia, M., & Bereiter, C. (2003). Knowledge building. *Encyclopedia of education*, (2) 1370-1373.
- Thagard, P. (1989). Explanatory coherence. *Behavioral and Brain Sciences*, (12), 435-467.
- Van Drie, J., & Van Boxtel, C. (2008). Historical reasoning: towards a framework for analyzing students’ reasoning about the past. *Educational Psychological Review*, (20), 87–110.
- Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in the work of nine and ten year-olds. *Educational Technology Research and Development*, 55:2, 117-145.

Acknowledgements

This research was funded by a grant from the Social Sciences and Humanities Research Council of Canada titled “Ways of contributing to dialogue in elementary school science and history.” We would also like to thank the students, teachers and principals of the Dr. Eric Jackman Institute of Child Study, University of Toronto.

An Educational Perspective: Research through Design

Heidrun Allert, Christoph Richter, Christian-Albrechts-Universität zu Kiel, Germany
 Email: allert@paedagogik.uni-kiel.de, richter@paedagogik.uni-kiel.de

Abstract: CSCL is concerned with theories of collaborative learning, respective educational practices and instructional models as well as the design and use of related technologies. The discipline needs to reflect the relation between research and design, analysis and synthesis, description and prescription. This paper focuses on the epistemological and methodological foundations of design and conceptualizes educational design as an object-bound process of inquiry entailing both knowledge generation and technology development.

The Relation between Research and Design & the Role of Knowledge in Design

As CSCL focuses on computer supported forms of collaborative learning an issue beyond deepening understanding and analysis of learning processes has to be addressed: How do insights gained from research and various theories of understanding and learning relate to the design of CSCL scenarios and technologies? How to relate descriptive analysis to prescriptive synthesis as we generate the conditions we observe and as our interventions transform reality? How do research activities in CSCL contribute to innovation in education and technology development? If we want to go beyond analysing learning processes and contribute to design (of interventions, learning scenarios, and technology alike) it is crucial to reflect design processes and conceptualize the role of knowledge in design. How to initiate and advance processes which create conceptual innovation in learning and teaching as well as knowledge in the field? In which form does CSCL research contribute to innovation in teaching and learning? This paper describes a *research through design* approach in the field of CSCL from an educational perspective. The approach draws on cultural-historical activity theory as epistemology and theory of “*transformative material activity*” (Miettinen, 2006). Research through Design relates the design of innovative learning scenarios to deepening understanding and scientific insight. Designing services and technologies is regarded as a form of knowledge work.

Several disciplines conceptualize the relationship between research and design, i.e. analysis and synthesis. Educational sciences and design studies among others are concerned with design as epistemic culture (Mareis, 2010, p. 178). In the field of CSCL we can distinguish various approaches, which differ concerning the relation of design and research. The approaches differ in at least the following aspects: (1) the role of knowledge in design; (2) the process to proceed from analysis to synthesis; (3) the status the generated knowledge has with regard to its generalization from local context. Some approaches describe design as applied science, assuming that the knowledge is prior to the design process. A different position with regard to the role of knowledge in design has been taken by the proponents of the design-based research approach, associated with the works of Brown (1992) and Collins (1992). This research approach aims to integrate the purposive design of pedagogical interventions and learning environments with the systematic investigation of the learning process taking place in these environments. This approach is characterised by the interleaving of design and theory building, an emphasis on the design of interventions that prove useful under authentic conditions, a theoretical anchoring of the design, an iterative approach of design, enactment, analysis and redesign, and the careful investigation of the effects of the intervention or learning environment (cp. Design-Based Research Collective, 2003). Even though the design-based research approach has been applied in a growing number of research and development projects, there is a still ongoing debate on the methodological foundations of this approach (e.g. Kelly, 2004). While a lot of the discussion has been centered around the question of scientific rigor the role of design in design-based research is quite underarticulated (cp. Bannan-Ritland & Baek, 2008). The approach presented in this paper conceptualizes design as knowledge creation and epistemic process. Design as object-bound inquiry aims at creating both, artefacts (products, services, interventions) and knowledge. Constitutive elements: (1) The co-evolution of analysis and design. Cross (1995): the co-evolution of problem and solution allows for understanding and investigating the problem. Generating a multitude of alternative solutions as a means to explore and understand the problem / design space. Drafting, conceptualizing and testing possible solutions allows for deeper understanding of the problem as implications and underlying assumptions are questioned and probed. The result, not the starting point of design is a deliberate description of the problem as well as knowledge about the design space. In a design space problem and solution are mutually dependent and in flux (emergent qualities). Design problems and contextualized scientific problems are open-ended and wicked: as soon as a problem is solved the solution is the sprout for a new problem. (2) the artifact as hypothesis: prototyping as inquiry allows to probe experiences and investigate emergent qualities & transformed practices. The artifact (product, service, intervention planned) is the hypothesis in the object-bound inquiry, derived by abductive reasoning. (3) the articulation of a design hypothesis, which takes into account the material and sign-related quality of the artifact (intervention/technology) used in inquiry. The conceptual and material (sign-related) quality of the artifact is assumed to have an effect on the findings and insights to be gained. (4)

describing the conditions and interventions (factors) and searching for generative mechanisms to explain a transformation. Whereas conditions are local, the generative mechanism explaining the transformation goes beyond the context given. Hedström & Swedberg (2005) define generative mechanisms as explaining the relation and transformation between two states. In sociology they are referred to as middle ground theories – being less universal than rules and laws, but more explanatory than descriptions of states and situations. We draw on the epistemic role of artifacts in processes of open-ended inquiry, and clarify the form of knowledge generated in design referring to a general design theory. The design process sketched here is referred to as practice-oriented design and is an alternative to approaches such as product-oriented design and user-oriented design. The co-evolution of analysis, synthesis, and contextual conditions is conceptualized as object-bound inquiry. Design is undetermined and allows for creative and reflective thinking. We draw attention to the grounding of design decisions (general design theory: Goldkuhl, 2004), the role of knowledge in design and the articulation of the knowledge generated in design. As the artifact can neither be derived deductively from scientific theory nor inductively from requirements and analyses, it is conceptualized a hypothesis. Also see approaches such as: *Research through Design* (Findeli et al., 2008), *Thoughtful Interaction Design* (Löwgren & Stoltermann, 2007), *Design as Knowledge Creation* (Allert & Richter, 2011). The iterative design process: (1) Framing a social phenomena. (2) Collecting information. (3) Exploring existing practices ((design) research methods, e.g. visualizing processes & practices in a journey framework). (4) Identifying tensions & analyzing critical events. (5) Stating a vision, taking up a position (projective step). (6) Drafting & sketching alternative design solutions to deepen exploration. (7) Explaining & explicating underlying assumptions of envisioned solutions. (8) Forming a design hypothesis & alternative hypothesis. (9) *Designing a prototype to probe underlying design assumptions*: Prototyping to probe in social context. (10) Exploring the use of prototype: emergent qualities & transformed practice. (11) Testing the design hypothesis, articulating design knowledge, modeling the design space (factors & generative mechanisms). (12) Explaining design related phenomena. (13) Forming further hypothesis & research questions. Acknowledgements. This work has been supported by the EU funded research project Knowledge Practices Lab.

References

- Allert, H. & Richter, C. (2011). Designentwicklung. In: S. Schön & M. Ebner (Eds). Lehrbuch für Lernen und Lehren mit Technologien. Retrieved from <http://13t.tugraz.at/index.php/LehrbuchEbner10>
- Bannan-Ritland, B., & Baek, J.Y. (2008). Investigating the Act of Design in Design Research: The Road Taken. In: A.E., Kelly, R.A. Lesh & J.Y. Baek (Eds.). Handbook of Design Research Methods in Education – Innovations in Science, Technology, Engineering, and Mathematics Learning and Teaching (pp. 299-319). New York: Routledge.
- Brown, A.L. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the Learning Sciences*, 2(2), 141-178.
- Collins, A. (1992). Toward a design science of education. In: E. Scanlon & T. O'Shea (eds.). *New Directions in Educational Technology*. Berlin: Springer.
- Cross, N. (1995). Discovering Design Ability. In: R. Buchanan, V. Margolin (Eds.). *Discovering Design: Explorations in Design Studies*. London: University of Chicago Press.
- Design-Based Research-Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, 32(1), 5-8.
- Findeli, A., Brouillet, D., Martin, S., Moineau, C., Tarrago, R. (2008). Research Through Design and Transdisciplinarity: A Tentative Contribution to the Methodology of Design Research. Bern: Swiss Design Network Symposium, 67-98.
- Goldkuhl, G. (2004). Design Theories in Information Systems — A Need for Multi-Grounding. *Journal of Information Technology Theory and Application (JITTA)*, 6(2), 2004, 59-72.
- Hedström, P. & Swedberg, R. (2005). *Social Mechanisms: An Analytical Approach to Social Theory*. Cambridge University Press.
- Kelly, A.E. (2004). Design Research in Education: Yes, but is it Methodological? *The Journal of the Learning Sciences*, 13(1), 115-128.
- Löwgren, J. & Stolterman, E. (2007). *Thoughtful Interaction Design: A Design Perspective on Information Technology*. Cambridge, MA: MIT Press.
- Mareis, C. (2010). Interferenzen zwischen Designwissenschaft und Wissenschaftsforschung. In: F. Romero-Tejedor & W. Jonas (Hrsg.). *Positionen der Designwissenschaft*. Kassel University Press.
- Miettinen, R. (2006). Epistemology of Transformative Material Activity: John Dewey's Pragmatism and Cultural-Historical Activity Theory. *Journal for the Theory of Social Behaviour*, 36(4), 2006, 389-408.

An Analysis of Teacher-Students Interactions in Three Science Classes: a Pilot Study

Naxin Zhao, Hedieh Najafi, James D. Slotta, Ontario Institute for Studies in Education, University of Toronto
Email: naxin.zhao@utoronto.ca, hedieh.najafi@utoronto.ca, jslotta@utoronto.ca

Abstract: This study examined the interactions between a veteran teacher and her students in 3 science classes. One of the classes was co-designed by the teacher and the researchers with the KCI model in mind. Teacher's enactments in the classroom were video-recorded. Results indicate that: 1) there are differences in teacher-students interaction among the three classes; 2) the teacher interacted with students equally in whole class and in small groups in KCI model of teaching.

This paper presents an analysis of the interaction between the teacher and the students in a technology-enhanced inquiry activity, by examining a veteran teacher as she used Cmap – a collaborative concept mapping tool – in three science class sessions. The following research questions have guided the analysis: 1) what are the overall patterns of teacher-students interactions in these three science classes? i.e. the frequencies and the percentage of time spent on each type of interaction; 2) are there any differences in terms of teacher-students interaction pattern between the KCI-oriented class session and non-KCI class sessions?

Research Method

This research is part of a broader program of work that investigated the teacher's role in Knowledge and Community Inquiry (KCI, Slotta & Peters, 2008) model. This study includes three iterations. The first iteration includes two class sections in the original KCI research where Cmap was used. Students worked in groups. Each group were asked to create one concept map. Students were allowed to add any concepts that they thought important to the concept map. In the second iteration, Cmap was used in the same two grade-eight class sections on cell science unit. Students were asked to create one concept map of his/her own without collaboration with peers. In the third iteration, Cmap was used in two grade-twelve class sections studying homeostasis. Students were asked to put some specific key concepts (i.e. homeostasis, endocrine system, osmoregulation, etc.) and their interrelationship in maps. Both iteration 2 and 3 were not part of an official KCI model. Video data analysis was used in this study. We used the coding scheme in Table 1 to analyze the video data.

Table 1: First level coding scheme for video data analysis.

Code	Full Name of Code	Meaning
WCI-L	Whole class interaction: logistical or procedural	The teacher provides procedural or logistical information to students in the whole class, such as talking about the agenda of a class or next class, managing students' behaviour, helping students solve technical difficulties, giving instructions on how to use software, etc.
WCI-C	Whole class interaction: conceptual	The teacher talks about science concepts or principles to students in the whole class.
WCI-P	Whole class interaction: pedagogical	The teacher gives instructions on what to do or suggests ways of thinking to students in the whole class.
SGL-L	Small group interaction: logistical/procedural	The teacher provides procedural or logistical information to students in a group, such as talking about the agenda of a class or next class, helping students deal with technological difficulties, giving instructions on how to use software, etc.
SGL-C	Small group interaction: conceptual	The teacher talks about science concepts to students in a group.
SGL-P	Small group interaction: pedagogical	The teacher gives instructions on what to do or suggests ways of thinking to students in a group.
Other		The teacher is not interacting with students.

Findings

Because in the third iteration, each class session was only about 15 minutes, we converted the absolute time spent on each interaction into time percentage. Figure 1 shows that the WCI-L (whole class logistical or procedural interaction, 16.61% of the total time of all interactions) and SGL-L (small group logistical or procedure interaction, 28.69% of the total time of all interactions) are the most frequent forms of interactions between the teacher and the students. This means that the teacher interacted with students most often to provide

procedural or logistical information, such as talk about the agenda of a class, help students deal with technological difficulties, either to the whole class or to students working in groups.

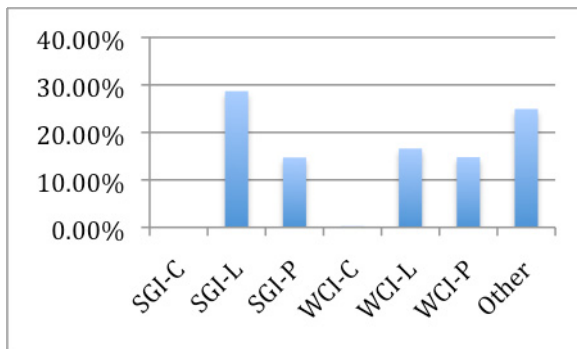


Figure 1. Time Percentage on Each Type of Interaction.

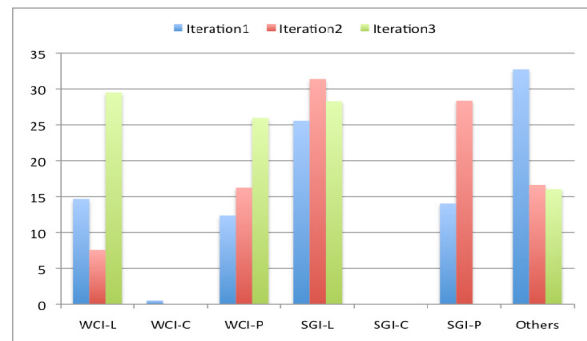


Figure 2. Time Percentage on Each Type of Interaction Compared among Three Iterations.

Figure 2 show the time percentage distributed in each type of interaction compared among the three iterations. The teacher had relatively more WCI-P in the third iteration, meaning that, in iteration three, the teacher interacted with students in “whole class” mode more often than she had done in the previous iterations. Most likely it is because of the shorter total duration of the class – there was a need for efficiency. A deeper analysis of the content of the teacher’s discourse disclosed that she gave many direct instructions that asked students to put specific concepts or keywords (i.e. homeostasis, thermal system, etc.) into their concept maps. The second iteration has relatively more SGI-L, meaning that the teacher interacted with students more often in small groups providing procedural or logistical information.

Figure 3 compares teacher-students interactions in terms of whole class interaction and small group interaction. Iteration 3 reflects that the teacher interacted with the students more often in whole class mode. This may reflect a traditional, teacher-centered way of teaching where the teacher gave many direct instructions, although the shorter duration class period may have influenced that greatly. The teacher had more small group interactions than whole class interactions in iteration 2, even though it was not part of any KCI or even an inquiry-oriented curriculum. However, as indicated in previous tables, even though the teacher interacted with students more in small groups, she did not use these interaction opportunities for pedagogical issues, but rather for procedural or logistical issues. In iteration 1, for which the unit was specially designed in KCI model, the teacher interacted with students relative equally in whole class and in small groups. Researchers believe that small-group learning processes are propitious to the development of higher order thinking (Noddings, 1989). Therefore, it is expected that, in KCI model, teacher should interact more with students working in small groups for pedagogical purpose.

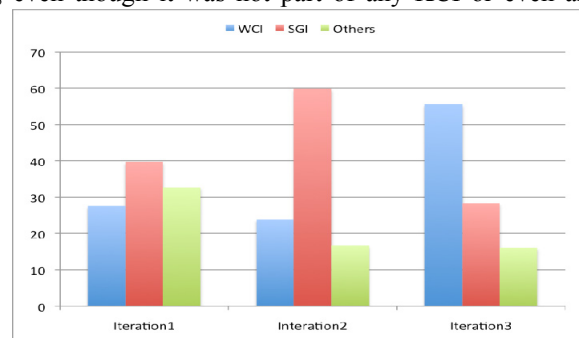


Figure 3. Comparison of Whole Class Interaction and Small Group Interaction among Three Iterations.

Conclusion

In learning sciences, there is a need to understand the dependencies of our innovations on classroom dynamics. Even if the classroom teacher is deeply involved in the design of the innovation (i.e., in co-design), the true nature of our interventions only takes shape during enactment. Thus, further research is needed to understand these dependencies. This study tried to create a description of the interaction between the teacher and the students by examining a veteran teacher using Cmap in three science classes. The results indicate that: 1) in these Cmap class sessions, there are differences in teacher-students interaction among the three science classes; 2) the teacher tended to interact with students equally in whole class and in small groups in KCI model of teaching than in traditional, teacher-centred model of teaching.

References

- Noddings, N. (1989). Theoretical and practical concerns about small groups in mathematics. *Elementary School Journal*, 89, 607-623.
- Slotta, J.D., & Peters, V. (2008). A Blended Model for Knowledge Communities: Embedding Scaffolded Inquiry. *Proceedings of the International Conference of the Learning Sciences*, Utrecht, The Netherlands.

Advancing a Complex Systems Approach to Personalized Learning Communities: Bandwidth, Sightlines, and Teacher Creativity

Eric Hamilton, Pepperdine University, Los Angeles, CA, eric.hamilton@pepperdine.edu

Abstract: Computer-supported collaborative learning (CSCL) has advanced one of the most important visions of educational reformers, to customize formal and informal learning to individuals. And, by its very nature, CSCL promotes connections between learners. A complex systems framework to the design of learning ecologies suggests that each of a series of ten desirable and malleable features stimulates or propels the other ten, interacting to create important emergent properties, such as personalized learning communities or the powerful blending of individualization within community.

Introduction

One of the most recurrent themes in the ascendancy of learning technologies over the past two decades has been the promise to furnish learners with personalized educational experiences (Dede & Barab, 2009; Martinez, 2001). This has been accompanied by recognition that traditional classroom structures, in contrast, reflect a sort of mass production paradigm for education and learning (Weigel, James, & Gardner, 2009). In one of the most famous papers in education research, Bloom asserted a two sigma achievement advantage of one-to-one tutorial instruction over typical classroom teaching (Bloom, 1984). Many explanatory factors have been advanced since publication of the two-sigma paper, including the immediacy of interaction between the student and the teacher and the ability of the teacher to furnish rapid feedback and to size up individualized instructional needs. As internet-based and socially-mediated technologies have given rise to computer-supported collaborative learning (CSCL), designs and affordances for more individualized educational experience have flourished even in contexts that are organized around group activity (Fischer & Scharff, 1998; Stahl, Koschmann, & Suthers, 2006). The expansion of affordances for individualization within technological advances for community implicitly speak to some of the most significant and historically challenging themes of education, of economics, of political systems, and more generally of human and social dynamics, to use a phrase the US National Science Foundation adopted for one of its recent programs (NSF, 2006). The rise of CSCL technologies is dramatically expanding the presence of personalization within community, and the pervasiveness of community within personalization. In education, this means that the collective (e.g., often classroom) experience no longer necessarily eclipses the needs of individual learners as much as in pre-digital formal classroom settings. Effective personalized learning communities routinely give space for individual members to engage in self-directed and personal preference-driven learning while connecting to a group whose identity coheres from the individual activities. Participatory simulations and MUVES (e.g., Barab & Dede, 2007; Wilensky & Shapiro, 2003) provide two of the most vivid PLC categories. These types of environments are designed to create a community experience out of the individual experience and vice versa.

Personalized Learning Communities Expressed As a Complex Systems Metaphor

This paper explores the possibility of personalized learning communities arising less out of explicit design than out of the interactions of a series of desirable characteristics or “primitives” for learning environments more generally. These characteristics appear in Figure 1. Hamilton and Jago (2010) describe an earlier version of these characteristics and outline a complex systems approach for how the characteristics interact dynamically with each other in one platform to produce higher order emergent effects – high value phenomena in education that are difficult to produce in mechanistic fashion but which represent sublime and high performance experiences for learners. Among such high value phenomena are vibrant personalized learning communities that routinely and expansively reflect and accommodate differences between - and preferences and needs of - its members through the process of immersion in meaningful collaborative experience. One primary rationale for developing a complex systems metaphor is that the salutary elements of Figure 1 seem to feed one another (Hamilton & Jago, 2010). These elements are not meant to be comprehensive nor a uniquely ideal formulation of salutary core elements of effective learning environments. Nor are they mutually exclusive: indeed, in a complex system, these elements overlap each other and become, to varying degrees, mutually implicative. Additionally, they are difficult to measure. Current technologies and metrics are insufficiently advanced to quantify them exactly. Notions of increased **interactional bandwidth** in a classroom, or increased emphasis on conceptual models and **modeling**, while resistant to single metrics, represent important phenomena, and their presence, absence or intensity can be intuitively understood. The value of such a summary partly rests in highlighting ingredients of learning ecologies that play off of each other, that augment each other, and that each is malleable. That is, each can be built into the design of learning experiences. The predictive value of using a complex systems approach is that desirable elements such as those appearing in Figure 1 will increase and

Table 1: Principles for personalized learning communities (adapted from Hamilton and Jago, 2010).

1. **Modeling:** Emphasis on models systems thinking and ways to represent connections between ideas. The relationships or operations between ideas becomes as salient as ideas
2. **Elicitation:** Emphasis on students expressing and representing the conceptual systems, intuitions and tacit understanding they already possess. “Draw out of ” instead of “put into” the student
3. **Consequentiality:** Emphasis on feedback loops in problem-solving, classroom, virtual world or other settings that are both meaningful to students and that are responsive to them
4. **Adaptivity:** Emphasis on iterative revisions in feedback or consequence-rich settings. Assessment regards improvement and revision processes as important as knowledge snapshots
5. **Interactional bandwidth:** Emphasis on diverse means to express content and meaningful human interaction in the learning environment. Includes: Sightlines or emphasis on creating powerful, diverse, and high-resolution fields of view for everyone in a classroom. Includes visualized representations of both cognition and content
6. **Customization:** Emphasis on matching high-feedback curriculum experience to individuals achievement levels and learning styles. Includes emulating personalized tutorial or mentoring
7. **Connectedness:** Emphasis on socialization including rich, multilayered connections between learners
8. **Self-regulation:** Emphasis on ability to search for and apply new knowledge, manage one’s participation in collaborative settings, tolerate ambiguity in unsolved problems, test ideas, reflect deeply on problems and frame intuitions
9. **Hybrids:** Emphasis on diversity of learning modalities and fluid transitions between them, such as between individual reflection and group immersion, between virtual words and real context; interoperability of individuals–social–machine knowledge forms, and heterogeneous competencies
10. **Generativity:** Emphasis on creativity and connections between ideas in problem-solving

reverberate through the system in ways that can produce emergent effects that resist linear design. The systems model requires different interpretations of cause and effect relationships in learning system design, whereby sometimes causes become effects and vice-versa. It is important to note that each Figure 1 elements represent multiple but related meanings. The notion of “sightlines” for example, or interactional bandwidth more broadly, covers a range of phenomena. Virtual worlds routinely furnish different ways to visualize the properties or elements a real, fictive, or blended environment. Animations generally furnish new ways to see mathematical or scientific structure. A social network map gives a picture of interactions between individuals. Each example represents a distinctive take on increased sightlines in a learning context and the broader notion of increasing its interactional bandwidth. Each of these features represents a rich trove or related meanings that vary in context.

References

- Barab, S., & Dede, C. (2007). Games and Immersive Participatory Simulations for Science Education: An Emerging Type of Curricula. *Journal of Science Education and Technology*, 16(1), 1-3.
- Bloom, B. (1984). The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational Researcher*, 13(6), 4-16.
- Dede, C., & Barab, S. (2009). Emerging Technologies for Learning Science: A Time of Rapid Advances. *Journal of Science Education and Technology*, 18(4), 301-304.
- Fischer, G., & Scharff, E. (1998). Learning technologies in support of self-directed learning. *Learning*, 98, 4.
- Hamilton, E., & Jago, M. (2010). Towards a Theory of Personalized Learning Communities. In e. (M. Jacobson & R. Reimann (Ed.), *Designs for Learning Environments of the Future* Springer Press.
- Martinez, M. (2001). Key design considerations for personalized learning on the web. *Educational Technology & Society*, 4(1), 26-40.
- NSF. (2006). *Human and Social Dynamics*. <http://www.nsf.gov/pubs/2006/nsf06604/nsf06604.txt>. National Science Foundation Publication 06-604.
- Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. *Cambridge handbook of the learning sciences*, 2006.
- Weigel, M., James, C., & Gardner, H. (2009). Learning: Peering Backward and Looking Forward in the Digital Era. *International Journal of Learning and Media*, 1(1), 1-18.
- Wilensky, U., & Shapiro, B. (2003). *Networked Participatory Simulations: Classroom Collaboration in Exploring the Dynamics of Complex Systems*. Paper presented at the CSCL 2003 (<http://www.intermedia.uib.no/cscl/interactiveevents/ia3.cscl>), Bergen, Norway.

Acknowledgments

The author expresses appreciation to the National Science Foundation, the Institute for Education Sciences, and the Microsoft Research for generous support of the research reported in this paper.

New Forms of Collaborative Repository Development Involving Students, Teachers, and Japanese Lesson Study

Eric Hamilton, Pepperdine University, Los Angeles, CA, eric.hamilton@pepperdine.edu

Abstract: This poster reviews a novel form of NSF- and IES- supported professional development research that explores teacher conceptual and pedagogical change as they develop a repository of videos of worked examples that shadow school curricula. Several elements are unique, including the creative role that teachers are expected to assume, the implementation of Japanese Lesson Study as the collaboration methodology for teacher interaction, and the involvement of student teams in creating peers for video.

Introduction

The expression “teacher creativity at the intersection of content, cognition and digital media” (Hamilton, 2010) captures much of the vision of this research this poster presents, research that challenges assumptions both about professional development and about digital repositories of learning objects, where the US National Science Foundation has made sizable investments, most notably in the National STEM Digital Library (NSDL) Program (National Science Foundation, 2010). Work in projects supported by NSF (Hamilton, 2010) and the US Department of Education (Hamilton & Harding, 2008) has been based on the conjecture that enabling teachers to exercise collaborative creativity in the form of teams that producing digital media could yield surprising and powerful results in the quest to accelerate and deepen student learning in high stakes accountability environments. The project thus focuses directly on teacher creativity. It also focuses on the process of drawing peer tutor students into the teaching community by engaging them in the effort to build by a cadre of student tutors working alongside their teachers. Together, in collaboration with Pepperdine University’s mathematics department, and drawing deeply on the methodology of Japanese lesson study, Los Angeles mathematics teachers and student tutors are creating a growing digital collection or repository of digital media reflecting the curriculum and standards of the four year high school sequence of standards that students are expected to master in high school.

Surface and Deeper Outcomes

This repository development is also fundamentally participatory and both teacher –centric and student-centric. Combined with the lesson study methodology, it relies on the collaborative, reflective and generative work of teachers for the substance of professional development in ways that elude even current reform practices (e.g., Darling-Hammond & Richardson, 2009). This approach to use lesson study to produce a living repository of creative mathematics lessons has two immediate and significant “surface” outcomes: a) finding practical means for teacher teams to build and exercise creativity through digital media is inherently rewarding and meaningful; it elevates the sense of professionalism and identity of teachers. Additionally, b) the repository becomes a dynamic and powerful resource that students come to use frequently to form robust mathematical knowledge, in contrast to many digital libraries. Beyond these two immediate benefits, it is becoming clear that more subtle and powerful teacher changes “beneath the hood” take place. The level of teacher sophistication both about cognitive pathways in mathematical development and about mathematics itself escalates significantly.

Video Creation

The notion of engaging teacher teams in digital object development originated in work by SRI, International and the TRAILS project that NSF funded in 2002 (DiGiano et al., 2002). TRAILS was designed in part to draw teachers into the mathematics applet development process. This effort contributed to the design of a project entitled “Agent and Library Augmented Shared Knowledge Area (ALASKA)” that includes the TRAILS PI (Chris DiGiano) and that NSF’s Computer Science Directorate supported (Hamilton, DiGiano, Cole, & Martin, 2004). Neither TRAILS nor ALASKA focused primarily on teacher development of media, and neither successfully realized the active teacher production of mathematical content in digital media. Researchers found that teachers did not have the time, energy, or technical software skills necessary to help create applets that would be useful in a classroom. The ALASKA project was oriented around integrating digital libraries with software agents and peer tutoring (Hamilton, 2005). The US Department of Education’s Institute for Education Sciences (IES) continued support of the ALASKA research, though, through a current Goal II R&D award (Hamilton & Harding, 2008) that re-conceptualized the mathematical object development of the project, based on work at the US Air Force Academy on sustaining learner engagement in mathematics classes (Hamilton & Hurford, 2007). That re-conceptualization shifted from producing mathematical applets from scratch to a) using a combination of tablet computers and screen video software to **create mathematical videos**, and b) using screen video software to make **existing applets or mathematical visualizations available in the National**

Science Foundation digital library repositories more usable in classroom settings. This re-work in the current ALASKA research has now produced two rounds of important interview and survey data that the poster will present. These interviews and surveys confirm the viability of the teacher creativity model. It came about as teacher teams in the pilot work found enormous satisfaction and excitement – not in what university professors or professional development experts imparted in professional development seminars, but in their own generative work. **Teacher teams authored materials that they tailored to the students they teach and to the standards for which they are accountable.**

Teachers Typically Excluded from Considerations of Creativity

We have observed that the prominent role of traditional textbook or reform curriculum producers, curriculum standards and policies, and the very limited time that teachers have outside of the classroom, all act to crowd out their creative potential to produce content tailored to their own student population, local standards, and the teaching styles they have found effective or appropriate for given settings. As in the past, mathematics and science teachers are not expected to be content *producers* but rather are content *conveyors*, following pre-defined curriculum in preparation for accountability tests. But at a time of unparalleled ascendancy of user-generated content in society more broadly (as evidenced by phenomena such as YouTube), teachers are strangely left out; mathematics teachers simply are not expected to be creative in producing content. At least, that is the message which comes through loudly when examining state and federal funding programs involving research and innovation in teacher professional development and teacher preparation. Creativity in education more generally, of course, is the subject in a broad range of the literature as well as in specialized research journals. There is robust research on ways to foster creativity **in students** (e.g., Kaufman & Sternberg, 2006). There is a strand of literature in school system administration that explores creativity and flexibility in **leadership** (McCallum, 1999). And, of course, there is an extensive body of literature and research support (especially from NSF) intended to **impart to teachers** creative and innovative instructional activities, materials, and full curricula. NSF review panels for other professional development programs (such as DRK12 or REESE) explicitly reward innovative and creative **researchers**, but ironically appear not to suggest directly that effort should be taken to focus on helping **teachers** understand, exercise, or benefit from their own creativity. With the exception of a very small number of researchers looking at only loosely related issues such as classroom improvisation (e.g., Sawyer, 2004) there appears to be little or no explicit guidance toward helping teachers to function as active and creative agents at the complex intersection of navigating mathematical content and student cognition. (Hamilton & Jago, 2010)

References

- Darling-Hammond, L., & Richardson, N. (2009). Teacher Learning: What Matters? *Educational Leadership*, 66(5), 46-53.
- DiGiano, C., Chung, M., Griffin, M., Huang, J., Knudsen, J., Pacpaco, R., et al. (2002). *Training and Resources for Assembling Interactive Learning Systems (TRAILS)*. NSF Grant 02-0563. SRI, Inc.
- Hamilton, E. (2005). Affective Composites: Autonomy and Proxy in Pedagogical Agent Networks. In J. Tao, J. Tan & R. E. Picard (Eds.), *Affective Computing and Intelligent Interaction (ACII2005)* (Vol. 3784, pp. 898-906). Berlin: Springer Lecture Notes in Computer Science.
- Hamilton, E. (2010). PREDICATE Project: Targeted Research on Teacher Creativity at the Intersection of Content, Student Cognition, and Digital Media: Award DUE104478, National Science Foundation.
- Hamilton, E., DiGiano, C., Cole, R., & Martin, D. (2004). *Agent and Library Augmented Shared Knowledge Areas (ALASKA)*: National Science Award 0420310.
- Hamilton, E., & Harding, N. (2008). IES Grant: Agent and Library Augmented Shared Knowledge Areas (ALASKA). *Institute for Education Sciences Award 305A080667*.
- Hamilton, E., & Hurford, A. (2007). *Combining Collaborative Workspaces with Tablet Computing: Research in Learner Engagement and Conditions of Flow*. Paper presented at the Proceedings of the 37th ASEE/IEEE Frontiers in Education Conference, Milwaukee, WI.
- Hamilton, E., & Jago, M. (2010). Towards a Theory of Personalized Learning Communities. In e. (M. Jacobson & R. Reimann (Ed.), *Designs for Learning Environments of the Future* Springer Press.
- Kaufman, J. C., & Sternberg, R. J. (2006). *The International Handbook of Creativity*: Cambridge University Press.
- McCallum, B. (1999). Literacy in Four Effective Schools. *School Leadership & Management*, 19(1), 7-24.
- National Science Foundation. (2010). National STEM Education Digital Library Program (<http://nsf.gov/pubs/2010/nsf10545/nsf10545.htm>).
- Sawyer, R. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. *Educational Researcher*, 33(2), 12.

AUTHOR INDEX

- Abels, Kristina, 1
 Abrahamson, Dor, 272
 Abrami, Philip, 756
 Adams, Anne, 916
 Aditomo, Anindito, 128
 Agrawal, Pulkit, 462
 Ahmad, S Zanariah, 1120
 Ahmad, Salman, 112
 Ahmet, Zeynep, 160
 Alagha, Iyad, 1081
 Alavi, Hamed, 350, 510
 Alcaniz, Mariano, 841
 Aleo, Franc, 160
 Allaire, Stephane, 900, 1168
 Allert, Heidrun, 1000
 Alterman, Richard, 240
 Amelung, Chris, 591
 Anastopoulou, Stamatina, 1202
 Arastoopour, Golnaz, 626
 Armitt, Gillian, 781
 Arnold, Franziska, 864, 1259
 Asensio-Perez, Juan, 1103
 Asher, Itay, 904
 Avouris, Nikolaos, 446
 Bagley, Elizabeth, 1214
 Bamberger, Jeanne, 992
 Banica, Dan, 771
 Bao, Xianqing, 1045
 Baumgartner, Adrian, 601
 Bauters, Merja, 1150
 Becher, Katharina, 1
 Beckers, Anna, 1
 Bereiter, Carl, 57, 571, 1089, 1111, 1123
 Berland, Matthew, 666
 Bertram, Johanna, 192
 Betrancourt, Mireille, 478
 Beuth, Jack, 398
 Bielaczyc, Katerine, 1089, 1111, 1123
 Blake, Canan, 726, 916, 1202
 Blancafort, Marta, 1178
 Blikstein, Paulo, 976
 Blondel, Francois-Marie, 846
 Bodemer, Daniel, 358, 962, 1065, 1170
 Bohm, Sonja, 716
 Boluda, Pere, 1178
 Bonnard, Quentin, 510
 Bopardikar, Anushree, 104, 731
 Boticki, Ivica, 168
 Boutin, Pier-Ann, 1178
 Boyer, Mark, 978
 Brennan, Karen, 342
 Brett, Clare, 960
 Breuleux, Alain, 856, 1134
 Brown, Scott, 978
 Brunger, Adrienne, 806, 934, 1081
 Buckley, Barbara, 1188
 Buder, Jürgen, 358, 374, 796, 962
 Bull, Susan, 761
 Burd, Elizabeth, 1081
 Bures, Eva, 756
 Caeiro-Rodriguez, Manuel, 691
 Cakir, Murat Perit, 534
 Calvo, Rafael, 128
 Chai, Shaoming, 898, 1045
 Chan, Anwar, 1073
 Chan, Carol K. K., 49, 914, 1053, 1111, 1139, 1207
 Chan, Lok Sze, 1185
 Chan, Tak-Wai, 646, 932, 944, 1289
 Chan, Yuen-Yan, 914
 Chang, Hsin-Yi, 1029, 1197
 Chang, Hsiu-Mei, 80, 944, 1264
 Chang, Yu-Hui, 858
 Chapman, Robbin, 970, 974
 Charles, Elizabeth S., 641, 866
 Chasteen, Michael, 696
 Chaves, Gina, 1154
 Chaves, Wendy, 1154
 Chen, Bodong, 571, 998, 1111, 1123
 Chen, Chih-Mao, 944
 Chen, Ching-Huei, 940
 Chen, Fei-Ching, 80
 Chen, Frank, 112
 Chen, Gaowei, 776
 Chen, Jennifer King, 1029
 Chen, Mark, 661
 Chen, Wenli, 144, 414, 454, 786, 836, 1015, 1037, 1073
 Chen, Xidiao, 1045
 Chen, Yen-Hua, 646
 Chen, Zhi-Hong, 932, 944
 Cheng, Gang, 1045
 Cheng, Jiaming 程佳銘, 1302
 Cheng, Kai-Tien, 80
 Cheng, Kenneth, 1159
 Cheong, Siew Kheng, 1120
 Chesler, Naomi, 626
 Chi, Ed H., 1010
 Chin, Chee-Kuen, 144
 Ching, Dixie, 671
 Chiu, Chieh-Hsin, 912
 Chiu, Jennifer, 984, 1029, 1197
 Chiu, Ming Ming, 64, 776, 1015
 Cho, Kwangsu, 1166
 Choi, Yin Wai Yvonne, 1185
 Chounta, Irene-Angelica, 446
 Chow, Chi Kin, 1175
 Choy, Chong Wah Cedric, 1120
 Chu, Ka Tim, 1175

- Chu, Samuel Kai Wah, 1148
 Chuy, Maria, 57, 571, 998, 1111
 Clegg, Tamara, 248
 Collier, Nicole, 964
 Collins, Trevor, 726, 916
 Condamines, Thierry, 486
 Constantinou, Constantinos, 904
 Constantinou, Costas P., 686
 Contero, Manuel, 841
 Coughlan, Tim, 916
 Coulter, Bob, 1023
 Craft, Brock, 1183
 Cress, Ulrike, 1, 192, 566, 864, 938
 Crider, Jeremy, 806, 934, 1081
 Cuendet, Sebastien, 510
 Daily, Shaundra, 974
 Damsa, Crina, 200, 470, 1095, 1150
 D'Angelo, Cynthia, 626
 Danish, Joshua, 216
 Dascalu, Mihai, 781
 Davies, Sarah, 916
 Davis, Sarah, 890
 Dayan, Jacob, 651, 1209
 de Jong, Frank, 821
 de Jong, Ton, 1202
 de Laa, Maarten, 1200
 de Laat, Hanneke, 821
 DeBarger, Angela Haydel, 518
 Dede, Chris, 902
 De-Groot, Reuma, 952, 1162
 Deguchi, Akiko, 896
 Deiglmayr, Anne, 676
 Delacruz, Girlie, 216
 Deng, Liping, 882
 Devlin, Alison, 874
 Dickinson, Anthony R., 656
 Dillenbourg, Pierre, 184, 350, 510, 1199
 Dimitracopoulou, Angelique, 741
 Dimitriadis, Yannis, 518, 1073, 1103
 Dohrmann, Patrick, 886
 Do-Lenh, Son, 510
 Dong, Zhijiang, 696
 Downton, Michael, 992
 Dubrowski, Adam, 990
 Dugdale, Michael, 641
 Dunleavy, Matt, 1023
 Duval, Erik, 1011
 Dyke, Gregory, 454, 1015, 1193
 Eberbach, Catherine, 982
 Edwards, Margaret, 1306
 Effendi, David, 890
 Elinich, Karen, 9, 870
 Ellis, Cali, 636
 El-Refai, Walid, 120
 Engler, Jan, 1202
 Enriquez, Rutchelle, 1029
 Enyedy, Noel, 216
 Erkens, Gijsbert, 200, 264
 Eseryel, Deniz, 586
 Evans, Michael A., 806, 934, 946, 1081
 Feenberg, Andrew, 756
 Fernandez, Eloy, 1103
 Ferreira, Deller, 888
 Fesakis, Georgios, 741
 Fields, Deborah, 701, 910
 Fischer, Frank, 120, 304, 382, 390, 406, 422, 438, 716, 894, 958, 1081, 1103, 1199, 1289
 Fraser, Danae Stanton, 1037
 Fu, Ella L. F., 49, 1239
 Fueyo, Vivian, 964
 Fukuda, Hiroyuki, 880
 Funaoi, Hideo, 880
 Fung, Yuen Han, 1053, 1139
 Fyfe, Vilma, 918
 Gao, Fei, 1296
 Gardner, Christina, 248
 Ge, Xun, 586
 Gehlen-Baum, Vera, 406
 Gentile, Sylvia, 216
 Georgiou, Agni, 721
 Gnesdilow, Dana, 104
 Gnoli, Alessandro, 1081
 Goel, Ashok, 982
 Goeze, Annika, 894
 Goggins, Sean P., 591
 Goodyear, Peter, 831
 Gorsky, Paul, 862
 Greene, Daniel, 976
 Grotzer, Tina, 902
 Gu, Xiaoqing, 1045
 Guichon, Nicolas, 478
 Guo, Shaoqing, 1045
 Guribye, Frode, 136
 Gutierrez, Jose, 272
 Gweon, Gahgene, 462
 Ha, Henry, 1175
 Hakkarainen, Kai, 948, 1089, 1111
 Håkløv, Stian, 1123, 1308, 1310
 Halatchliyski, lassen, 566, 1254
 Hamalainen, Raija, 631, 946
 Hamel, Christine, 900
 Hamilton, Eric, 1004, 1006, 1154, 1312
 Hansson, Lena, 904
 Harding, Nancy, 1154
 Harrer, Andreas, 1103, 1162
 Hasenbein, Melanie, 616
 Hatch, Andrew, 176
 Haussmann, Annette, 1
 Heo, Gyeong Mi, 856
 Hernandez, Juan Carlos, 986
 Hernandez-Leo, Davinia, 1103
 Herodotou, Christothea, 904
 Herrmann, Thomas, 811, 938
 Hesse, Friedrich W., 152, 374

- Hewitt, Jim, 960
 Higgins, Steve, 176, 1081
 Hirashima, Tsukasa, 880
 Hmelo-Silver, Cindy, 550, 982, 1013, 1289
 Ho, K. C., 1164
 Hoadley, Christopher, 671, 1013, 1207
 Hong, Huang-Yao, 858, 912, 1111
 Hong, Ming, 912
 Honwad, Sameer, 982
 Hoppe, H. Ulrich, 986, 1202
 Howley, Iris, 366
 Hsiao, Ying-Ting, 88, 711
 Hsieh, Fang-Pei, 1029
 Hu, Chun, 918, 1126
 Hu, Zhiwen, 1294
 Hubscher, Roland, 1013
 Hui, Diane, 656, 1139
 Hundertmark, Sarah, 924
 Hunter, Judith, 990
 Hussmann, Heinrich, 716
 Idris, Sufian, 621
 Ilomaki, Liisa, 502, 1150
 Im, Jungtaek, 1166
 Inagaki, Shigenori, 896
 Ioannou, Andri, 721
 Ishiguro, Hiroshi, 1205
 Jacobson, Michael, 1126
 Jaeger, Allison, 1081
 Janssen, Jeroen, 200, 326
 Jeong, Heisawn, 454, 550, 786, 1015
 Jermann, Patrick, 184, 510
 Jing, Leng, 1168
 Johansson, Carolina, 160
 Jonassen, David, 1059
 Jones, Ann, 726
 Jonsson, Martin, 160
 Jordan, Rebecca, 982
 Joyce-Gibbons, Andrew, 176
 Jurgens, Alke, 886
 Kaendler, Celia, 676
 Kafai, Yasmin, 17, 701, 910, 1013
 Kahrmanis, Georgios, 446
 Kai Chan, Keung, 1159
 Kali, Yael, 651, 831, 1209
 Kam, Matthew, 671
 Kamarainen, Amy, 902
 Kamvar, Sep, 112
 Kanda, Takayuki, 1205
 Kangas, Kaiju, 851
 Kaplan, Frederic, 510
 Kapur, Manu, 1065, 1126, 1170
 Karlgren, Klas, 1150
 Kartiko, Iwan, 1126
 Kawasaki, Miho, 988
 Kay, Judy, 25
 Kennedy-Clark, Shannon, 596, 706, 878
 Kerawalla, Lucinda, 726
 Kim, Beaumie, 920
 Kim, Gwang-Jo, 1009
 Kim, Jihie, 892
 Kim, Mi Song, 920
 Kimmerle, Joachim, 1, 566
 Kirschner, Paul A, 264, 326
 Kita, Chigusa, 112
 Klopfer, Eric, 1023, 1130
 Knickle, Kerry, 990
 Knight, Katherine, 224
 Knipfer, Kristin, 938
 Koedinger, Kenneth R., 334
 Koh, Quee Boon, 1029
 Kohen-Vacs, Dan, 681, 1103
 Kohnle, Carmen, 958
 Kollar, Ingo, 120, 382, 390, 422, 946, 1081
 Kollias, Vassilis, 904
 Kolodner, Janet, 248, 1053
 Koper, Rob, 766
 Kopp, Birgitta, 616, 736
 Krauskopf, Karsten, 152
 Krumm, Andrew, 868, 1234
 Ku, Yiu Yee, 1159
 Kubota, Yoshihiko, 930
 Kumar, Melissa, 216
 Kumar, Rohit, 398
 Kurti, Arianit, 681
 Kusunoki, Fusako, 896
 Kwok, Ching Yin, 1185
 Kwok, S. M., 1164
 Kynigos, Chronis, 1162
 Kyza, Eleni, 904
 Kyza, Eleni A., 686
 Laferrière, Thérèse, 900, 1111, 1134, 1168, 1178
 Laffey, James, 591, 816
 Lai, Ming, 33, 581
 Lakkala, Minna, 502, 1150
 Lally, Vic, 874
 Lam, Bonnie, 1164
 Langer, Sybille, 422
 Lapeyre, Jaime, 990
 Larusson, Johann, 240
 Lasry, Nathaniel, 866
 Lau, Alison, 1159
 Lau, Siu Fan, 1185
 Laurillard, Diana, 526, 1183
 Law, Nancy, 33, 208, 526, 581, 882, 936, 1015, 1139,
 1164, 1168, 1178, 1291
 Law, Victor, 586
 Lawless, Kimberly, 978
 Lax, Leila, 990
 Lea, John, 916
 Lee, Chwee Beng, 1059
 Lee, Hsueh Chien Dawn, 1120
 Lee, Namseok, 1166
 Lee, Shuh Shing, 884
 Lee, Sunghye, 1029

- Lee, Yeung, 526, 882, 1164
 Lee, Yew-Jin, 1120
 Lei, Chunlin, 1269
 Lei, Jing, 1029
 Leng, Jing, 872
 Leung, Lawrence, 208
 Lewis, Armanda, 860
 Li, Cen, 696
 Li, Kangli, 1045
 Li, Kedong, 1045
 Li, Na, 1273
 Li, Yanyan, 1045
 Liao, Calvin C. Y., 932
 Lin, Chiu-Pin, 646
 Linn, Marcia, 994, 1029
 Lit, Shirley, 1175
 Liu, Lei, 826
 Ljubojevic, Dejan, 1183
 Loll, Frank, 296, 980
 Lomas, Derek, 671
 Lonn, Steven, 868
 Looi, Chee-Kit, 168, 414, 454, 646, 786, 836, 1015, 1037, 1073, 1199
 Lopez, Oscar Hernandez, 1178
 Loser, Kai-Uwe, 811
 Lu, Jingyan, 882, 936
 Luckin, Rosemary, 611, 1037
 Ludvigsen, Sten, 470, 1095
 Lui, Michelle, 430, 641, 990, 1081, 1143
 Lund, Kristine, 454, 1015, 1207, 1306
 Luo, Heng, 1029
 MacLennan, Cameron, 990
 Madeira, Cheryl Ann, 558, 966, 968
 Makitalo-Siegl, Kati, 958
 Maldonado, Heidy, 1202
 Maldonado, Luis Facundo, 986
 Mandl, Heinz, 616, 736
 Mann, Susanna, 746
 Marbouti, Farshid, 88, 711
 Maria, Chuy, 1123
 Markauskaite, Lina, 596, 831
 Martin, Taylor, 666
 Martinez, Roberto, 25
 Martínez-Monés, Alejandra, 1195
 Mathews, Jim, 1023
 Matschke, Christina, 864
 Matteucci, Maria Cristina, 736
 Matuk, Camillia, 994, 1029
 Mavrikis, Manolis, 1162
 Mayfield, Elijah, 366, 438
 McGillion, Michael, 990
 McLaren, Bruce, 980, 1162
 Medina, Richard, 454, 1015
 Mercier, Emma, 176, 1081
 Messina, Richard, 1053, 1123
 Metcalf, Shari, 902
 Michael, Georgia, 686
 Milrad, Marcelo, 681, 1202
 Miyake, Naomi, 96, 1059, 1205
 Mochizuki, Toshio, 930
 Moher, Tom, 1081
 Molinari, Gaele, 1065, 1170
 Montané, Mireia, 1178
 Moraveji, Neema, 112, 876
 Morley, Elizabeth, 1053, 1123
 Moskaliuk, Johannes, 192, 864
 Motto, Andrea, 806, 934, 1081
 Mous, Karel, 1029
 Mu, Jin, 406, 438
 Mu, Su, 898
 Mullins, Dejana, 184, 676
 Muukkonen, Hanni, 1095, 1150
 Najafi, Hedieh, 996, 1002
 Namdar, Bahadia, 1029
 Nancy, Law, 1045
 Nasser, Samira, 904
 Nelson, Suzanne, 890
 Newstead, Anne, 1126
 Nicolaido, Iolie, 904
 Notari, Michele P., 601
 Nussbaum, Miguel, 1199
 Nüssli, Marc-Antoine, 184
 O'malley, Claire, 1202
 Oksanen, Kimmo, 631
 Oldershaw, Cally, 904
 Ortega, Mario, 841
 Oshima, Jun, 1015, 1111, 1200
 Paavola, Sami, 1150
 Palaiodimos, Aggelos, 741
 Papanastasiou, Elena, 721
 Park, Jonghwi, 866
 Parussel, Karla, 874
 Patel, Kishan, 671
 Patton, Charles, 542
 Patton, Charlie, 1073
 Pea, Roy, 152, 876, 1012, 1202
 Pei, Xinning 裴新宁, 1304
 Penuel, William, 518, 1073
 Peppler, Kylie, 17, 992
 Perez-Lopez, David, 841
 Perez-Rodriguez, Roberto, 691
 Perreault, Christian, 1168, 1178
 Perrotta, Carlo, 946
 Perry, Judy, 1023, 1130
 Peters, Vanessa, 926
 Peterson, Patricia, 928
 Petrick, Carmen, 666
 Phielix, Chris, 326
 Pilz, Florian, 1081
 Pinkwart, Niels, 296, 886, 980
 Plesch, Christine, 676
 Poon, Tung Keung, 1159
 Porte, John, 1126
 Prié, Yannick, 478

- Prieto, Luis P., 518, 1073, 1249
 Prilla, Michael, 938
 Prins, Frans, 326
 Puntambekar, Sadhana, 104, 224, 731, 1013, 1037
 Raes, Annelies, 751, 922, 1219
 Raj, Bhiksha, 462
 Rausch, Andreas, 886
 Reale, Nathan, 696
 Rebedea, Traian, 771, 781
 Redfors, Andreas, 904
 Reedy, Gabriel B., 972
 Reffay, Christophe, 846, 1195
 Reilly, Mark, 908
 Reimann, Peter, 128, 746, 1059
 Ren, Youqun 任友群, 1302
 Resendes, Monica, 57, 571, 998, 1111, 1123
 Reynaud, Stéphane, 1306
 Richards, Debbie, 706, 1126
 Richter, Christoph, 1000, 1150
 Ritella, Giuseppe, 948, 1089
 Robb, Anja, 990
 Rogers, Yvonne, 916
 Ronen, Michaela, 1103
 Ronen, Miky, 681
 Rosberg, Maria, 904
 Roschelle, Jeremy, 542, 1073, 1199
 Rose, Carolyn P., 366, 398, 438, 462, 1015, 1193
 Rosenheck, Louisa, 1023, 1130
 Roy, George, 964
 Rudat, Anja, 962, 1224
 Rugaber, Spencer, 982
 Rummel, Nikol, 334, 676, 1065, 1170
 Rusman, Ellen, 766
 S. Quellmalz, Edys, 1188
 Saarivesi, Eini, 1150
 Saballus, Ulf, 904
 Saito, Moegi, 96
 Salvador-Herranz, Gustavo, 841
 Sami, Rahul, 636
 Sánchez, Mayra Fabiana Angeles, 1283
 Sander, Birgit, 950
 Sarmiento-Klapper, Johann, 534
 Sasaki, Hiroshi, 930
 Sato, Elissa, 994
 Sawyer, Keith, 1015
 Scanlon, Eileen, 726, 1202
 Scardamalia, Marlene, 57, 571, 998, 1053, 1089, 1111, 1123
 Schank, Patricia, 518, 1073
 Schanze, Sascha, 904, 924
 Schellens, Tammy, 751, 922, 1219
 Scheuer, Oliver, 980
 Schmidt, Matthew, 816
 Schooneveld, Jackie Van, 870
 Schrader, Josef, 894
 Schubert, Kai, 950
 Schwarz, Baruch, 1162
 Schwendimann, Beat, 954, 956, 1029
 Schwind, Christina, 374, 796
 Sclater, Madeleine, 874
 Seitamaa-Hakkarainen, Pirita, 851, 948, 1089, 1111
 Shaffer, David Williamson, 626
 Shao, Yin-Juan, 646
 Shapiro, R. Benjamin, 494, 1023
 Shaw, Erin, 892
 Sheldon, Josh, 1023
 Shen, Haifeng, 908
 Shen, Ji, 1029, 1197
 Shen, Rui 沈睿, 1300
 Shin, Ho-Chul, 1166
 Shirouzu, Hajime, 988, 1015, 1205
 Showalter, Stephen, 928
 Silva, Brenda López, 1081
 Sim, Chor Miang, 1120
 Sinha, Suparna, 982
 Sloep, Peter, 766
 Slof, Bert, 264
 Slotta, James D., 430, 558, 641, 966, 968, 996, 1002, 1045, 1081, 1143, 1308
 Smith, Garrett, 731, 1278
 So, Hyo-Jeong, 41
 Songer, Nancy, 926
 Southavilay, Vilaythong, 596
 Spada, Hans, 676
 Speer, Jennifer, 88, 711
 Spikol, Daniel, 942, 1202
 Spreeuwenberg, Lia, 821
 Squire, Kurt, 1023
 Stahl, Gerry, 256, 534, 1089
 Stegmann, Karsten, 382, 406, 438, 716, 1103
 Steinmeier, Christopher, 9, 870
 Stichter, Janine, 816
 Stieff, Mike, 288
 Streng, Sara, 716
 Strijbos, Jan Willem, 1015
 Subramaniam, Nantha Kumar, 621
 Sugimoto, Masanori, 896
 Sullivan, Sarah, 224
 Sumon, Saiful, 160
 Sun, Daner, 1029
 Sun, Jizhen, 168
 Sun, Yanqing, 72
 Suthers, Daniel D., 454, 1015, 1200
 Suzuki, Hideyuki, 930
 Svihla, Vanessa, 232
 Tabak, Iris, 904, 1037
 Takeda, Yoshiaki, 896
 Tan, Esther, 41
 Tan, Seng Chee, 1059
 Tarchi, Christian, 1123
 Tauzia, Vincent, 1306
 Taylor, Charlotte, 1126
 Taylor, Meredith, 1126
 Teasley, Stephanie, 868

- Tee, Meng Yew, 884
 Teplovs, Christopher, 846, 1015, 1168, 1200
 Thiel, Ansgar, 1
 Tholander, Jakob, 160
 Thompson, Kate, 596, 706, 878
 Tian, Stella, 914
 Tissenbaum, Mike, 430, 641, 1081, 1143, 1308
 Tohyama, Sayaka, 1244
 Toikka, Seppo, 1150
 Tomasetto, Carlo, 736
 Toyama, Yukie, 542
 Trausan-Matu, Stefan, 771, 781, 906, 1015
 Trninic, Dragan, 272
 Tsai, Pei-Chen, 858, 912
 Tse, Andrew Chung Yee, 1159
 Tse, Hidy, 1053
 Tucker, Sean, 9
 Tutwiler, M. Shane, 902
 Twiner, Alison, 726
 Tzeng, Ren-Yow, 80
 Udani, Mikesh, 462
 Unal, Zafer, 964
 Underwood, Joshua, 611, 1037
 Untch, Roland, 696
 Vahey, Phil, 964
 Valbuena, Widman Said, 986
 Valcke, Martin, 766
 van Aalst, Jan, 454, 914, 1015, 1053, 1059, 1111
 van Bruggen, Jan, 766
 van de Sande, Carla, 280
 van der Meij, Hans, 904
 van Heijst, Hennie, 821
 Vanderhoven, Ellen, 751, 922
 Vanover, Charles, 964
 Varma, Keisha, 1197
 Vatrappu, Ravi, 606, 761
 Viilo, Marjut, 1111
 Villagra-Sobrino, Sara, 518, 1073
 Vogel, Bahtijar, 681
 Waddington, Richard, 868
 Wagner, Christine, 716
 Wake, Jo Dugstad, 136
 Walker, Erin, 334
 Wan, Wing-San, 914
 Wang, Haiyan, 1308
 Wang, Joyce, 9, 870
 Wang, Lu, 1045
 Wang, Po-Hsien, 858
 Wang, Xinghua, 382
 Wang, Xueli, 920
 Wang, Zhan, 776
 Ward, Mary-Helen, 831
 Wardrip, Peter, 494
 Warnecke, Tim, 886
 Wasson, Barbara, 136
 Watt-Watson, Judy, 990
 Wecker, Christof, 304, 390, 422, 1103
 Wegerif, Rupert, 312, 888, 1162
 Weibert, Anne, 950
 Weinberger, Armin, 1065, 1170
 Wen, Yun, 414, 836
 Westermann, Katharina, 1229
 Wever, Bram De, 751, 946
 Whittaker, Chris, 641, 866
 Wichmann, Astrid, 1202
 Wiley, Jennifer, 1081
 Wilkins, Jesse L.M. (Jay), 806, 934, 1081
 Winters, Niall, 611
 Wise, Alyssa Friend, 64, 88, 711
 Wong, Lung-Hsiang, 144, 168
 Wong, Wai Yat, 918, 1126
 Wong, Wing, 1168
 Woo, David James, 801
 Wu, Chun-Ping, 319
 Wu, Hsin-Kai, 1029
 Wu, I-Chia, 940
 Wu, Jing, 576, 1120
 Xie, Charles, 1029
 Xin, Cindy, 756
 Xu, Hui, 1045
 Yacef, Kalina, 25
 Yamaguchi, Etsuji, 896
 Yamasaki, Kazuya, 880
 Yang, Euphony F. Y., 944
 Yang, Xianmin, 1045
 Yang, Yang, 312, 1162
 Yeh, Charles Y. C., 932
 Yeo, Jennifer, 576, 1120
 Yip, Jane, 1175
 Yoo, Jaebong, 892
 Yoon, Susan, 9, 826, 870
 Yu, Fu-Yun, 319
 Yu, Qiong 俞琼, 1302, 1304
 Yu, Shengquan, 1045
 Yuen, Johnny, 791, 1168, 1178
 Zahn, Carmen, 152
 Zeini, Sam, 1200
 Zhan, Yi 詹艺, 1302, 1304
 Zhan, Ying, 144
 Zhang, Baohui, 1029
 Zhang, Jianwei, 57, 72, 1053, 1111, 1123
 Zhang, Yonghe, 1168
 Zhao, Jian, 1045
 Zhao, Jianhua, 898, 1045
 Zhao, Naxin, 996, 1002, 1308
 Zhou, Nan, 534
 Zin, Abdullah Mohd, 621
 Zong, Hua 宗华, 1298
 Zottmann, Jan, 894
 Zufferey, Guillaume, 510