



computer-supported collaborative learning

July 4-8, 2011 🌸 Hong Kong, China

Connecting research  
to  
policy and practice

Conference Proceedings Volume III

**Community events proceedings:**  
Keynotes, symposia, practitioner-oriented events,  
pre-conference, and post-conference

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



International Society of  
the Learning Sciences



Centre for  
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Connecting computer-supported collaborative learning to policy and practice

**CSCL2011 CONFERENCE PROCEEDINGS**  
**VOLUME III**  
**COMMUNITY EVENTS PROCEEDINGS**

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# 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.

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## Volume III



**Community events proceedings:  
Keynotes, symposia, practitioner-oriented events,  
pre-conference, and post-conference**



# Part 1



# Keynotes

## Linking Research and Policy Practice Towards Quality Learning: Why and How?

Gwang-Jo KIM

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### Summary

The reason for the question of "why" seems rather obvious: There have been ever-growing demands on education reform to prepare students for the 21<sup>st</sup> century skills yet research on learning does not seem to provide a clear guidance as to how and what to reform, not to mention massive investment on ICT in education that still requires justification. Given these arguments, I would thus raise the second question — the question of "how": How could we improve quality of learning through linking research on learning and educational policy and practice? More specifically, how can research on ICT-supported learning inform educational policies to promote access, equity, efficiency and quality of education? To this end, I will review and present the trends in both research and policy practice in the Asia-Pacific region and beyond. I will also introduce some of the initiatives that UNESCO Asia-Pacific Bureau for Education undertakes to create evidence-based supportive environments for policy makers for the effective ICT-pedagogy integration. Further areas and projects that need research-informed frameworks will be discussed to invite researchers for collaborative opportunities.

# Augmented Social Cognition: How Social Computing is Changing eLearning

Ed H. CHI  
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## Summary

Our research in Augmented Social Cognition is aimed at enhancing the ability of a group of people to remember, think, and reason. Our approach to creating this augmentation or enhancement is primarily model-driven. Our system developments are informed by models such as information scent, sensemaking, information theory, probabilistic models, and more recently, evolutionary dynamic models. These models have been used to understand a wide variety of user behaviors, from individuals interacting with social bookmark search in Delicious and MrTaggy.com to groups of people working on articles in Wikipedia. These models range in complexity from a simple set of assumptions to complex equations describing human and group behaviors. Indeed, increasingly, new social online resources such as social bookmarking sites and Wikis are becoming central in eLearning. By studying them, we further our understanding of how knowledge is constructed in a social context. In this talk, I will illustrate how a model-driven approach could help illuminate the path forward for social computing and social learning.

## On the Importance of Being Open...

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### Summary

In this talk, I will discuss some of the meanings of the word 'open' in relation to learning - open source, open standards, open educational resources, open on-line courses, ... are some of the terms I may refer to. The emphasis will be on the added value of openness and transparency. Maybe we'll discuss some problems and dangers too. I will definitely show some concrete examples of our work in this area. And I would value an opportunity to talk about the lack of impact of much of our research, the importance of experimentation and the value of failure (as an opportunity to learn).



## **CSSL Opportunities and Challenges in the Context of the US National Educational Technology Plan**

Roy PEA

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### **Summary**

In November 2010, the US Secretary of Education released the National Educational Technology Plan for the United States, which presented a model of 21st century learning powered by technology, with goals and recommendations in five integrated areas: learning, assessment, teaching, infrastructure, and productivity. The NETP also identified a set of Grand Challenge Problems which should be tackled in large-scale, long-term, coordinated research within and beyond the US that could help make this vision a reality. As one member of the Technical Working Group that researched and wrote this NETP document, I welcome the opportunity to reflect on the radical nature of its fundamental ideas, the integrated nature of our recommendations for these five areas, and how the national policy environment and private-public partnerships are influencing its implementation in the United States. Global work on the Grand Challenge Problems would be desirable yet we lack coordinating bodies and mechanisms.

# Part 2



# Symposia

## ISLS Presidential Sessions: Honoring Janet Kolodner

### Co-Chairs

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### Introduction

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### Remarks

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### Abstract

Janet Kolodner was the founding editor of The Journal of the Learning Sciences, who over two decades led the journal and the field to a prominent place in educational research. She was also one of the founders of the International Society of the Learning Sciences. In this session, representatives of the current editors of JLS and of ISLS presidents discuss Janet's contributions and the current state of the journal and the society. In addition, a number of Janet's former postdoctoral fellows discuss their present research and its ties to their work with Janet.

## Towards Productive Multivocality in the Analysis of Collaborative Learning

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**Abstract:** Research in Computer Supported Collaborative Learning (CSCL) is diverse and multi-vocal, in that multiple theoretical and methodological traditions speak to questions concerning how learning takes place in social settings. Whether this multivocality leads to balkanization or is a source of strength may require deliberate efforts at identifying strategies and finding boundary objects for productive discourse across this diversity. This paper and associated symposium reports on the results of such an effort—a four-year series of five workshops exploring the basis for productive dialogue between multiple analytic traditions in CSCL. After a brief introduction to our objectives and the series of workshops, we illustrate lessons learned with three examples in which a group of analysts deliberately chosen for their diversity analyzed three small corpora with respect to identifying “pivotal moments” in collaborative learning and compared their results. The project also illustrates more generally the potential value of collaborative learning among researchers.

### Introduction

Researchers in Computer Supported Collaborative Learning (CSCL), and more generally in the Learning Sciences, take multiple approaches to the study of how interaction leads to learning with the support of designed artifacts. The CSCL community is an international community (Kienle & Wessner, 2006) consisting of researchers, designers and practitioners from diverse fields, drawing largely on computer science, education, educational psychology, human-computer interaction, and psychology, as well as linguistics and other educational, information, learning, and social sciences (Wessner & Kienle, 2007). Hence numerous theoretical frameworks and methodological traditions drive work in the field. This multivocality is a strength only to the extent that there is sufficient commonality to support dialogue between the “voices” and reach some degree of coherence in the discourse of CSCL (Suthers, 2006). The Learning Sciences are too diverse (theoretically and methodologically) for unification to be possible or desirable, but learning scientists would benefit from *boundary objects* (Star & Griesemer, 1989) that form the basis for dialogue between theoretical and methodological traditions applied to the analysis of learning in and through interaction. The question at hand is what constitutes effective boundary objects and how they may be leveraged.

Over the past three years, the authors and other colleagues have collaborated through a series of workshops to address this question, seeking appropriate boundary objects and strategies for supporting productive multi-vocality between multiple analytic traditions in CSCL. This paper provides an initial report of our activities and lessons learned. We start with a brief history of the project. Then we use three case examples to illustrate the value of multivocal analyses and lessons learned concerning strategies and barriers to overcome. The purpose is not to report on specific analyses, nor to claim that these analyses are complete and offer significant results. Rather, the purpose is to offer to the CSCL community what we as a collective have learned, from comparing our analyses, about how to collaborate as analysts and take advantage of theoretical and methodological diversity. An activity of this scope cannot be described adequately in a conference paper. More detailed accounts will be provided in a symposium at the CSCL 2011 conference, and in journal articles and a book that are being planned at this writing.

## History

Our collaborations developed through a series of workshops at the International Conference on the Learning Sciences (ICLS) 2008, Computer Supported Collaborative Learning (CSCL) 2009, the STELLAR Alpine Rendez-Vous (ARV) 2009, and ICLS 2010. Below we describe the motivations for each workshop and how major lessons learned led to changes in our strategy in each subsequent workshop.

### A Common Framework for CSCL Interaction Analysis (ICLS 2008)

A premise of our first workshop was that common conceptions, representations, and tools are needed to support and bridge between multiple theoretical perspectives as well as facilitate the application of different analytical methodologies and tools to complex data sets. Progress in any scientific discipline requires that practitioners share common objects such as instrumentation, data sources, analytic methods, etc. that enable researchers to replicate or challenge results. Shared instruments and representations mediate the daily work of scientific discourse (e.g., Latour, 1990; Roth, 2003), and advances in other scientific disciplines have been accompanied with representational advances. Similarly, we reasoned, researchers studying learning in distributed and networked environments need shared ways of conceptualizing and representing what takes place in these environments to serve as the common foundation for our scientific and design discourse.

The goal of our first workshop (organized by authors Suthers, Law, and Rosé, and Nathan Dwyer) was to establish requirements for a common conceptual and representational framework to support collaborative learning process analysis, by (a) demonstrating our analytic tools to one another in the context of analyses we had conducted, (b) identifying commonalities among these tools and analyses along four dimensions, and (c) generating requirements for a common conceptual model and abstract transcript that might also form the bases for shared analytic software. The dimensions were (1) purpose of analysis, (2) the units of interaction that are taken as basic in the analysis, (3) representations of data and analytic interpretations, and (4) analytic manipulations taken on those representations. We found that the dimensions were helpful for characterizing diversity, but we realized that our multivocality presented challenges in identifying a single common conceptual and representational framework for analysis. Yet, we felt we were gaining some understanding from looking at each other's analyses. A “tool fair” also generated considerable interest, and we noted the need to make our theoretical assumptions explicit.

### Common Objects for Productive Multivocality in Analysis (CSCL 2009)

In our second workshop (organized by authors Suthers, Law, Lund, Rosé, and Teplov), we decided to tackle multivocality head-on by having analysts from different traditions assigned to analyze the same data set. Two corpora were used, from the Virtual Math Teams and Knowledge Forum. We continued to use the four dimensions to characterize different analyses, and added the dimension of (5) theoretical assumptions underlying the analysis (which permeate the other dimensions, e.g. Ochs, 1979). We examined our analytic processes to discover commonalities along the five dimensions that can support productive multivocality. We also sought to determine whether analytic differences are complementary (potential sources of richer understanding) or incompatible (potential barriers to a common discipline). We found that our commonalities did not fall along the dimensions, but rather were that we shared (a) learning through collaborative interaction as our topic of study, and (b) the desire and willingness to engage in this activity together. Also, we found that multiple analyses of shared data corpora provided a promising basis for dialogue, but noted that there were disconnects between the analyses presented because the analysts were approaching these corpora with entirely different questions. This observation led to the objective of identifying “pivotal moments” in the next workshop.

### Pinpointing Pivotal Moments in Collaboration (ARV 2009)

Our third workshop (organized by Lund, Law, Rosé, Suthers and Teplov) continued the prior strategy of having researchers from different theoretical and methodological traditions analyze shared data corpora. We used a different Knowledge Forum corpus, and a Japanese primary school mathematics class exemplified later in this paper. As before, we assigned analysts to data, deliberately pairing up analysts from different methodological traditions, and assigning some analysts to data from settings they did not normally study. We addressed the prior mismatch in analytic objectives by asking analysts to identify “pivotal moments” in collaborative learning. The definition of pivotal moments was purposefully left unspecified, providing a projective stimulus that drew out different researchers' assumptions and insights and leading to exciting comparative and integrative discussion. As expected, analysts differed in their conception and identification of pivotal moments, but these differences (as well as some congruencies) generated productive discussion of how learning arises from interaction. In this workshop we first articulated our current strategy for multivocality: assigning diverse analysts to shared corpora with analytic objectives that are deliberately open to interpretation (e.g., “pivotal moments”). During this and the prior workshop, our own objectives shifted: we talked less about sharing the *same* concepts or representations; and more about *boundary objects* (such as the corpora and pivotal moments) supporting dialogue between different traditions. Boundary objects “have different meanings in

different worlds but their structure is common enough to more than one world to make them recognizable, a means of translation” (Star & Griesemer, 1989, p. 393). Yet we wanted to explore further how shared frameworks (e.g., Suthers, Dwyer, Medina, & Vatrappu, 2010) and shared analytic software tools (e.g., Tatiana; Dyke, Lund, & Girardot, 2009) could serve as or produce appropriate boundary objects.

### Productive Multivocality in the Analysis of Collaborative Learning (ICLS 2010)

In our fourth workshop (organized by Lund, Suthers, Law, Rosé and Teplovs), we sought to build on the success of the third workshop; replicating the strategy of having deliberately diverse analysts identify pivotal moments in shared corpora. There were two novelties. First, we brought in new data corpora and new analysts. Corpora included a Group Scribbles mathematics classroom in Singapore and university level chemistry study groups in the U.S (both are exemplified later in this paper). Second, we wanted to revisit the possibility that a shared software tool and its data and analytic representations would help support more detailed comparisons between analyses, by providing all the data and analyses within the common tool. This latter effort enabled analyses to be shared ahead of the workshop and is reported in (Dyke et al., 2011). The primary strategy again proved to be productive, surfacing issues and insights exemplified by the case studies below. In the remainder of the paper, we briefly summarize the lessons learned from comparing the analyses of the three data corpora identified in the above historical account.

### A Multi-vocal Analysis of Pivotal Moments for Learning Fractions

*Summarized by Kris Lund. Data and analysis provided by Hajime Shirouzu. Additional analyses by Ming Chiu and Stefan Trausan Matu.*

The data concerns six students studying the multiplication of fractions in a 6<sup>th</sup> grade classroom in Japan. Their task was to cut out  $\frac{3}{4}$  of  $\frac{2}{3}$  of a piece of origami paper and then to discuss whether or not their solutions were the same. A teacher led and monitored activity. Work was carried out both on the blackboard and by folding pieces of paper. Video data was supplied and the Japanese was transcribed, translated into English and synchronized with the video as subtitles. Drawings of each student’s folded origami solution were also provided. Three analysts were asked to detect the pivotal moments occurring in the interaction and were given the latitude to define this as they wished.



The first analyst and data provider, Hajime Shirouzu, defined pivotal moments as occurring when a learner reflects on his or her own externalized results of problem solving or that of others with the result that either individuals or the collective achieve conceptual change: pivotal moments can be either individual or collective. Shirouzu found three collaborative pivotal moments. First, the class as a unit reached a new level of understanding when the dialogue illustrated a collective display of abstract dimension (e.g. the areas could be equal for two different paper foldings, but the shapes and ways of folding could differ). A second pivotal moment was when a learner withdrew his diagrammatic explanation in spite of another learner’s strong support (e.g. “is this wrong?” “that’s ok!”). Finally, a third pivotal moment occurred when an algorithmic explanation was collectively approved (e.g. “when  $\frac{2}{3}$  is multiplied by  $\frac{3}{4}$ , the product is  $\frac{6}{12}$  and it is equal to  $\frac{1}{2}$  after being reduced, all [answers] are  $\frac{1}{2}$  of the whole”). Shirouzu took the individual as his unit of analysis and, based on convergence/divergence theory, tracked both intra and inter-mental activities as displayed by or inferred from the interaction (Shirouzu & Miyake, 2002).

The second analyst, Ming Chiu, defined time periods that were divided by five pivotal moments, also described as *breakpoints* (Chiu, 2008), where one description of activity changes to another (e.g. from teacher instructions to student folding to looking at one another’s solutions). He observed that pivotal moments could differ across cognitive problem spaces vs. social relational spaces and across separate high vs. low micro-creativity time periods. Whereas Shirouzu qualitatively noted three pivotal moments of high-level thinking, Chiu identified six time periods of distinctly different frequencies of new ideas. Each conversation turn was coded across five variables (evaluation of the previous action, knowledge content regarding problem, validity, justification, invitation to participate). On top of this first coding scheme, *micro-creativity* was defined as occurring when a new idea was mentioned that was also correct and a correct evaluation was either agreeing with a previous speaker’s correct idea or disagreeing with a previous speaker’s wrong idea. Breakpoints were defined statistically wherein the fewest breakpoints described the most variance in quantity of new ideas. Chiu had to adapt his technique for use on a small dataset. In such a case, although statistical results may not be significant, they still suggest specific relationships to explore qualitatively.

The third analyst, Stefan Trausan-Matu, defined pivotal moments in collaboration by detecting changes in the degree of inter-animation of voices as illustrated by collaborative and differential utterances. *Collaborative* utterances illustrate a convergence pattern and correspond for example to the collective display of understanding already mentioned (Shirouzu’s first pivotal moment and Chiu’s fifth breakpoint). An example of

a *differential* utterance is when an explanation given by one learner is perceived as incomplete, thus inciting a second learner to add to it. In the polyphonic view, this exemplifies a type of “dissonance” between the two learners that is remedied by the second learner’s addition. Trausan-Matu used a polyphonic model of group interaction where a conversation contains different longitudinal threads (or “voices”) composed of utterances, each of them having independence, but achieving a joint discourse (Trausan-Matu & Rebedea, 2009). He found four groups of collaborative pivotal moments or sequences, and differential pivotal moments within these collaborative sequence. These collaborative sequences overlapped in every case with the three pivotal moments defined by Shirouzu and in one case with Chiu. All of the three analysts identified one pivotal moment in common: the display of new collective understanding referred to earlier. Discussions of differences between these analyses led to several conclusions concerning productive multivocality, discussed below.

Each researcher focused on a different unit of analysis (pivotal moments of either reflection on externalized results of problem solving or changes in the degree of inter-animation of voices, vs. time periods of different frequencies of new ideas punctuated by breaking points). Shirouzu and Trausan-Matu described sequences of turns as pivotal moments because they focused on moments of collaboration and dissonance/divergence, whereas Chiu restricted his breakpoints to a single conversation turn, as his goal was to divide the interaction into distinct periods. These differences in focus of attention reflect both how questions spurred by underlying theoretical frameworks (intra-mental interaction, convergence, divergence, micro-creativity) guide the eye, and how criteria for applying particular analytical techniques influence choice of the unit of analysis, although all analysts were able to use Shirouzu’s method for segmenting the interaction.

The pivotal moments and breakpoints only intersected once: Shirouzu’s first pivotal moment was Trausan-Matu’s second and comparable to Chiu’s fifth breaking point. Shirouzu sees this moment as a collective display of new understanding and tries to explain it through individual trajectories whereas Trausan-Matu explains it as resulting from the characteristics of individuals (e.g. divergent thinker). Both analysts draw inferences on individual thought processes from the interaction, but employ different methods based on different epistemological views on how the individual relates to the collective. Chiu views this moment as indicating the end of a period of frequent ideas, occurring just after teacher acknowledgment. Indeed it is compatible that the moment when collective understanding is reached could correspond to the beginning of a drop in new ideas because learners are consolidating their knowledge in terms of concepts already expressed. Re-examining this moment in terms of Chiu’s definition of ideas as “new” or “old” led Shirouzu to suggest that in his framework, new ideas could correspond to conceptual or procedural changes to how to view the solutions, progressing potentially towards a collaborative pivotal moment. A lesson for multivocality related to confronting one analysis with another is that it leads to fine-tuning of analytical concepts, explanations of why analysts did not converge and thus to a better comprehension of the phenomena studied while rendering researchers’ epistemological views explicit. Also, sharing analyses can widen perspectives on how the data can be interpreted: Shirouzu studied Chiu’s five breaking points and noticed that frequency of new ideas corresponded to when and how the pedagogical designer’s intentions were actualized by students’ behavior.

Since gestures were transcribed by Shirouzu, Chiu and Trausan-Matu took them into account, considering that some gestures exhibited new ideas or displayed collaborative or differential positions that could signal a pivotal moment. An important issue for sharing data and methods arose that involved applying the polyphonic framework to data other than chat interactions. It was shown that inter-animation and polyphony appears also in non-verbal interactions (e.g. all learners move their chairs except one); thus the analytical framework’s reach was extended to new types of previously unconsidered data.

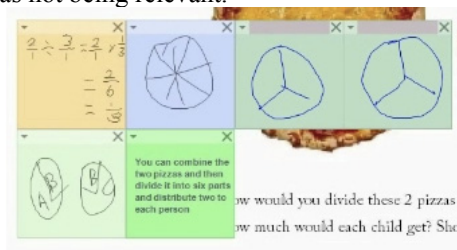
In summary, comparison of approaches and results showed that analysts realized how theoretical frameworks guided the way they looked at their data (Lund, 2011), but they were still able to match new meanings to the interpretations of others (in different frameworks) that were relevant to them. Analytical concepts such as convergence, dissonance and ideas were fine-tuned as a result of comparing analyses and led to better understanding of the phenomena studied. Units of analysis were critical for orienting interpretations, but the segments chosen by Shirouzu were sufficient for the analyses carried out by Chiu and Trausan-Matu. Using individual threads to explain collaborative outcomes was a consistent approach across analysts. However, comparisons of analyses surfaced different beliefs concerning how individual participation in the collective can be measured and comparison made this explicit. Parallel qualitative and statistical analyses revealed both the same and different pivotal moments. Such mixed-method analyses of pivotal moments can mutually inform each by triangulating results and/or stimulating further qualitative or statistical analyses to shed further light on the identified pivotal moments and/or breakpoints. Finally, sharing data that had gestures transcribed incited analysts to consider gestures in their analysis, an aspect of interaction they did not usually consider.

## **A Multi-vocal Analysis of Small Group Problem Solving Using GroupScribbles**

*Summarized by Gregory Dyke and Dan Suthers. Data and analysis provided by Chee-Kit Looi and Wenli Chen. Additional analyses by Heisawn Jeong, Richard Medina, and Jan van Aalst.* The process of analysis consists, in part, in the transition from the empirical domain of the interaction (speech utterances and events in the software

environment) to the conceptual or epistemological domain of the analytic framework (e.g. ideas, representational practices, knowledge building, social cognition, etc.). This transition is effected through a representational domain (e.g. spreadsheets, transcripts, contingency graphs, etc.). In combining four analyses from the perspectives of uptake, knowledge building and group cognition, we found that agreement on how the representational domain mediates between the empirical and conceptual domains facilitates productive discussion in the conceptual domain. Our multi-vocal discussion revealed that, while all analytic frameworks gave a similar account of the interaction, thus validating this account, their interpretations with regard to learning varied, each raising questions for the other frameworks. These questions served as catalysts for the improvement of the analyses, and could also prompt extension or validation of the underlying frameworks through adoption of new constructs or the explicit rejection of others as not being relevant.

The analyses focus on a sixteen-minute excerpt from a three-year school based project. During this excerpt, four students in a Singapore primary school interact verbally and via the Group Scribbles software (Roschelle et al., 2007) to solve and contrast solutions to the problem of dividing two pizzas equally among three children. They must then examine and comment on the solutions provided by other groups. All four analyses agreed on the following account of the interaction: Helen and Victor both formulate similar graphical solutions and agree on their equivalence. Terry seems unable to come up with a graphical solution and, after having verbalized this difficulty and seen Helen and Victor's solution writes an equivalent textual solution. Quentin develops his own symbolic solution (which contains an error) without interaction with the others. While commenting on solutions of other groups, Helen appropriates a colored version of her representation, Terry demonstrates his understanding of the various representations, and Quentin corrects his solution. The interaction is dominated by off-topic activity by Victor, and his peers' reactions to this activity.



Richard Medina's analysis was conducted using concepts and methods from the uptake analysis framework (Suthers et al., 2010). Analysis of contingencies and interpretation of uptake across both verbal and inscriptional acts showed that Helen, Victor and Terry demonstrated a specific orientation to inscriptional activity and artifacts in their interaction. Of particular interest is Terry's comment, "You can combine the two pizzas and then divide it into six parts and distribute two to each person," provided after a brief sequence of negotiation with Helen and Victor. In terms of uptake, this is a pivotal moment not so much because it demonstrates Terry's views on the problem (and his verbalization of Helen's inscriptional proposal) but rather because it is a punctuation of a sequence of talk and inscription among Helen, Victor, and Terry. Terry's proposal stands against both Helen and Victor's proposals even though he aligns it with Helen's. In this instance we can notice that the single action is not isolated from its social and material contingencies. Identifying Terry's punctuating comment as an instance of uptake of representational practice as well as ideas requires some unpacking of the action leading up to his conclusion. Seeing this analytically requires a perspective shift from individual acts to relations between acts.

Chee-Kit Looi and Wenli Chen's analysis (Looi & Chen, 2010) also utilized uptake analysis. In spite of being conducted independently from the Medina analysis, a strikingly similar uptake graph resulted. They specialized uptake categorically into agreement, disagreement and incomprehension in order to further unpack semantic relatedness. This provides a more complete account of Helen and Victor's attitudes towards their respective solutions. They also note the isolation of Quentin, wondering how his symbolic solution would have benefited from mutual understanding with the other solutions.

Jan van Aalst's analysis examined the data from a knowledge building perspective (Scardamalia, 2002) and found that, after a promising start with four different ideas being shared, there is only minimal discussion about the two graphical solutions, implicit agreement with their textual equivalent and no coordination with the (initially incorrect) symbolic solution. Because the students had not appropriated practices oriented towards idea improvement and synthesis they only did so after instruction by the teacher. This suggests that they have not taken control of the learning opportunities offered to them.

Heisawn Jeong's analysis examined the interaction from a cognitive interpretation of group cognition. She took the artifacts created by the group as a proxy for the group understanding and examined how group understanding as reflected in the contents of the group space evolved over time. 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. Solutions in the form of drawings and formulas were not integrated, and the group space remained fragmented. Her analysis also examined how each contribution emerged from artifact-mediated discourse. The majority of the contributions were collaborative in that students provided prompts and questions in the process. Unlike typical verbal discourse, however, the collaboration was mediated by both verbal and non-verbal activities in the GS workspaces as students interacted verbally as well as through comments and checkmarks on the contributions



The representational coordination of these analyses was conducted using the Tatiana conceptual framework and software (Dyke et al., 2009). Initial comparison appeared to show wide discrepancies in interpretation, but closer examination showed that these were mostly gratuitous differences resulting from conflicting choices as to the granularity of the unit of analysis and whether or not private spaces were considered. Medina's analysis tracked the uptake of both ideas and representational practices over time, interpreting spoken and inscriptional acts in relation to prior acts. Looi & Chen's analysis was concerned only with the uptake of ideas attributed to inscriptions in the public space, and differentiated uptake relationships according to agreement, disagreement and incomprehension. Van Aalst's analysis was also concerned with ideas, but analyzed ideas expressed both in private and public spaces. Jeong's analysis introduced the concept of a contribution thread that includes all contributions around the same core idea. Although initially the analyses differed on whether they looked primarily at verbal data and whether private events were included, discussion between analysts led to agreement to examine all public events (verbal utterances and published notes). A subsequent iteration of analysis showed that none of the analyses laid claim to anything specific or differentiating with regard to their empirical foundations, enabling focus to shift onto how the different analyses complemented each other and the questions they raised.

The combination of these analyses allowed a clearer understanding to emerge. The contingency graphs unpacked the interaction, making contingencies explicit. Following each contribution as it evolved in the group space helped show that uptake (from the Medina analysis) not only happens across students, but also across contribution threads (from the Jeong analysis), highlighting the focal points for learning. The knowledge building perspective showed the missed opportunities where new ideas (in particular Quentin's solution) were not taken up by others and contributed to the fragmentation of the group space. All analyses, in spite of their very different theoretical frameworks, showed that this interaction was sub-optimal. Each, however, would perhaps suggest different methods for improvement. Further questions were raised surrounding conceptual issues such as our positions with regard to off topic and "disruptive" behavior; how to theorize concepts for which empirical grounds are implicit or missing, such as contingencies implicit in students' visual orientation, hypothesized cognitive events, and missed opportunities; and relationships between interaction, individual learning, intersubjective meaning-making, and knowledge building.

We drew three important lessons from this multivocal collaboration: First, an important first step is to eliminate gratuitous differences in the scope of data to be analyzed so that essential differences can be foregrounded. Second, once this is done, comparisons can draw analysts out of their epistemological cocoons as they encounter different interpretations that challenge their own. Third, shared representations of data and analyses can serve as boundary objects in both of these processes.

## **A Multi-vocal Analysis of Peer Led Team Learning for Chemistry**

*Summarized and analyzed by Carolyn Rosé; Data provided by Keith Sawyer. Additional analyses by Jun Oshima and Jan-Willem Strijbos.* One advantage as well as challenge of multi-vocal approaches to analysis of collaborative learning interactions is that it reveals the ways in which our individual operationalizations of complex constructs such as *leadership* are limited. In bringing together analyses from multiple perspectives addressing similar issues with the same dataset, our eyes opened to the richness and complexity of how these constructs are embodied in language. Here we bring together five frameworks for analysis of leadership to analyze interactions from Peer-Led Team Learning (PLTL) groups in an undergraduate chemistry class, specifically two categorical coding schemes specifically designed to analyze collaborative learning discussions, two coding schemes designed to capture aspects of social positioning within discussions, and a social network analysis approach designed to make patterns of exchange apparent to analysts.

Our analysis focuses on transcripts of two different groups working on the same presented problem. These two groups in particular were chosen from a complete set of 18 groups because they demonstrate two very different approaches to group problem solving; one group (the *Gillian* group) focused on deeper conceptual understanding while the other group (the *Matt* group) was more narrowly focused on identifying the appropriate algorithm to determine the correct answer. In this presentation, we examine the synergy between multiple analyses through the lens of exploring relative authoritativeness and receptivity within the discussions as two separate constructs related to leadership. All three analysts agreed that the Gillian group had a clear leader, whereas leadership within the Matt group was more diffuse. However, finer grained analyses revealed important distinctions that reveal how each of these operationalizations is limited, and how we can deepen our understanding of complex constructs such as leadership through multi-vocal analysis. We consider the idea of leadership from two directions, first in terms of how authoritative a speaker presents him or herself as being, and second, in terms of how receptive other group members are to a member's positioning of him or herself as a leader, as indicated by their conversational responses.

Let us first consider the issue of authoritativeness in presentation of self. Jun Oshima's innovative word level network analysis was accomplished by quantifying and comparing "social relationships" between words within discourses. To this end, a social network analysis methodology was applied, whereby an edge

represented a co-occurrence relationship between words within contributions to a discourse. Influential students identified in this analysis were those who used words that appeared in central locations within the graph. One student emerged as a central player within the Gillian group, but none emerged within the Matt group. The same student was identified as authoritative within Jan-Willem Srijbos' analysis. In this case, authoritativeness was measured by patterns of occurrence of turns labeled as *Dominance+* and *Dominance-*, where positive dominance statements show leadership through positive polarity statements, such as declaring an idea as correct, while negative dominance statements show leadership through negative polarity statements, such as providing corrections or challenges. The Rosé analysis approached the idea of leadership through two constructs from the field of systemic functional linguistics, namely Martin and Rose's negotiation framework (Martin & Rose, 2003) and Martin and White's operationalization of heteroglossia (Martin & White, 2005). In the negotiation framework, authoritativeness is demonstrated by making a contribution to a discourse that is not offered as an invitation for validation from another group member. For example, an assertion that is made in response to a question that is framed as a hint rather than a serious question, and then followed by an evaluation, is not coded as an authoritative assertion. Based on this analysis, the Rosé framework identified the same student as authoritative that the Oshima and Srijbos analysis did. However, the heteroglossia framework painted an alternative picture. Within that framework, assertions framed in such a way as to acknowledge that others may or may not agree are identified as heteroglossic. Such assertions can be either *expanding*, adding to the set of items up for negotiation, or *contracting*, eliminating items from consideration. This can be seen as similar to the notion of positive dominance and negative dominance within the Srijbos framework, and frequently there is a correlation between these two constructs. However, it is not always the case that heteroglossic assertions that are framed as negative polarity statements perform the function of contracting the set of options under negotiation. For example, if a constraint is eliminated, then more items are made negotiable since fewer constraints need to be satisfied. This subtle distinction between the Srijbos and Rosé approaches to measurement of leadership lead to differences in how students were ranked in the less clear cases. Furthermore, while the student identified as authoritative by all three analysts was identified as having more negative dominance statements in the Srijbos analysis and one might expect that student to have more contracting than expanding heteroglossic statements, that student had more expanding statements.

Receptivity of leadership as evidenced by the response of other group members is another dimension along which interesting differences emerge in the investigation of leadership within the Chemistry discussions. Within the Oshima analysis, a much higher level of interconnectivity was evidenced within the Gillian group. High levels of vocabulary sharing could indicate higher levels of receptivity between students. In the Srijbos analysis, receptivity was indicated through Collaborative Orientation vs. Individual Orientation codes. Similar to the Oshima analysis, Srijbos identified the Gillian group as having more Collaborative than Individual utterances, whereas the Matt group was the opposite. In the Rosé analysis, however, receptivity is analyzed through identification of "transactive" contributions, which operate on reasoning displayed in a prior contribution (Berkowitz & Gibbs, 1979). If the Rosé analysis was consistent with the Oshima and Srijbos analyses, we would see more transactivity in the Gillian discussion, but interestingly, the opposite turns out to be the case. This is because although the discussion was focused on moving step by step through the problem rather than discussing concepts at length, the Matt group reasoned out the problem solving steps together, checking each other's work. This multi-vocal analysis of receptivity to leadership reveals how quantitative approaches to analysis of such constructs may inadvertently adhere too tightly to shallow features of interactions, such as the way highly transactive exchanges appear in conceptually oriented discussions, and thus miss valuable interactions occurring where the focus is more procedurally focused.

In looking at these 5 different analyses, a multi-faceted image of ideal leadership emerges that would not be visible from any one of the analyses. For example, our multi-vocal separation between different leadership constructs allows us to see how it is possible to present one's views as standing on their own without denying others the right to have their own voice. With such a multi-vocal analysis, we can see how few leaders have mastered both aspects. Furthermore, a person who presents him or herself as authoritative might be more likely to elicit receptivity from his or her collaborators, but it may not always be the case for various reasons. Thus, this multi-vocal analysis has a greater potential as an assessment framework for identifying where strong but not stellar leaders may need improvement.

## Conclusions

Sharing analyses has benefits both for the individual analysts and the community. Analysts are confronted with aspects of the data highlighted by others that they might not have themselves considered; epistemological assumptions are challenged; analytic concepts are fine tuned; and a multidimensional understanding of the phenomenon being investigated and analytic constructs used to approach it is gained. The process leads to greater dialogue and mutual understanding in our community. Productive multivocality is facilitated by eliminating gratuitous differences in the scope and representation of data considered, and by deliberately pairing diverse analysts charged with a common yet flexible analytic objective. At this writing, a fifth workshop is

planned for the Alpine Rendez-Vous in March 2011, in which we will add further multivocal analyses to our experience base, and complete our planning for a book on our project.

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## Augmented Reality Games: Place-based Digital Learning

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**Abstract:** Educational augmented reality (AR) games engage users as participants in a motivating experience with technology in the real world. Carrying handheld computers, players move from place to place in real space to interact with virtual information that has been programmed to help them learn about topics of the game designer's choice. In this symposium, four researchers and practitioners with a combined more than two decades of experience with AR games will examine issues to be considered for implementation of augmented reality games for learning and the future directions for the research field. Among others, these issues will include assessing claims of learning through AR games, the value of such games as a tool for place-based education, the value of authoring vs. simply playing AR games, and the claim that using handheld computers for an AR game building experience benefits, rather than distracts participating students.

### **Introduction**

Players of augmented reality (AR) games use handheld computers, often common smartphones, to interact with virtual information that is connected to real-world spaces. For example, players of TimeLab2100, a game built using the MIT Augmented Reality (MITAR) platform, travel the MIT campus armed with GPS enabled smartphones that enable them to interact with virtual guides. These guides help the players to experience the campus as it might be nearly 100 years in the future. As they move across campus with the guides, the GPS in the phones tracks the player's location on the map. The players see icons that represent themselves move across a map shown on the screen of the smartphone.

As they walk through the play-space, players also observe other, stationary icons on the map. When they move close enough to one of these other icons, information that is some combination of text, images, audio or video is triggered on the phone. At each location, the virtual guides, fictional MIT graduate students in the related fields of political science and climatology, engage the players in dialog about the possible consequences global climate change might have on the campus. With this information, the players consider which laws could be passed now to ameliorate either the causes or the symptoms of global climate change years from now with the goal of learning about causes and consequences of climate change, as well as what we can do about it.

Each of the three educationally focused augmented reality game technologies used by the panelists for this symposium, MITAR, developed at the MIT Scheller Teacher Education Program in partnership with the Missouri Botanical Garden; ARIS, developed at the University of Wisconsin-Madison; and ROAR, developed at Radford University, share similar technical features, however each has its own unique affordances, developed to

best serve the learning goals of their target audiences and the research agendas of the teams building the software. Of course, the software is a means to an end, and is most interesting in what it allows its users, whether those users are playing games or both building and playing the games, to do. Similarly, the actions that one takes in the games, and the way they are designed are based on slightly different takes on theories of engagement and learning.

In his book, *Augmented Learning*, Klopfer (2008), the moderator for this symposium, details some of the considerations that led to the design of Outdoor Augmented Reality software from MIT, an early and formative example of AR games software and a precursor to MITAR. In this symposium, he will use his experience leading one of the early and ongoing educational AR games programs to probe differences between implementations of educational augmented reality games by the panelists. Issues to be considered include: building tools that afford student authorship of games to foster constructionist learning; what qualities teachers and other practitioners must possess to implement an AR games curriculum successfully; AR games as part of a place-based education model; claims that using handheld computers for AR game authorship and playing enhance learning activities rather than provide distractions; and perhaps most important for any educational technology intervention, how to assess claims of disciplinary learning during the play of AR games. Each of the sections below represents a piece of the emerging research agenda around AR games and demonstrates the experience and thinking of the panelists with regard to augmented reality games. The issues mentioned below will serve as a starting place for panel discussion.

### **Forging Students' Connection to Place**

Augmented reality games and simulations have great potential to forge a productive synergy between the documented benefits of students exploring their local community and the educational potential of handheld technology (Roschelle & Pea, 2002). This work also brings the added benefits of getting students out in the community through service learning projects, thereby addressing the pressing need to engage students in opportunities to build their identities around citizenship and stewardship.

As an educational approach, place-based education immerses students in their immediate community, using this local angle as the context and motivation for student inquiry. Thus, instead of studying water quality as an abstract idea, or learning about a great river system hundreds or thousands of miles away, students in a place-based approach use their local creek as the basis for learning core academic concepts. From this basis in real-world investigation, students extend their understanding, scaffolded by the conceptual structures they built in their community. Drawing on a decade of research, the Place-based Education Evaluation Collaborative (2010) has documented a range of educational benefits, including increased levels of students' academic achievement, community involvement, and stewardship, as well as enhanced teacher motivation, school culture change, and increased school-community partnerships.

Augmented Reality (AR) games and simulations extend the benefits of a place-based educational approach, as they provide opportunities for students to build relevant STEM-related skills both directly through their innovative use of hand-held technologies and game design software, and indirectly through the use of on-screen simulations to model aspects of scientific or historic research that would not be possible outside of the AR environment. Imagine that students are investigating a water quality mystery and need to conduct sophisticated monitoring that is too expensive for a school budget. This process can be simulated "in place" with the student scientists conducting a test when they reach the appropriate site along the creek banks. Similarly, students investigating local history can "conduct" interviews with people ordinarily not available but who can appear in a video via the handheld units. Emerging research is helping to discern and document the optimal balance of authentic first-hand experience and simulated experiences made possible in an AR environment. (Coulter et al., in press)

A third program leg being developed by the LIONS and CSI programs (jointly run by the Missouri Botanical Garden and MIT) is the promotion of service learning opportunities emerging from the AR simulations. With the increased interest and understanding generated through the game environment, students are better motivated and able to engage in community action projects that serve to improve their community. In turn, students' experiences with these projects extend their understanding to create a virtuous learning cycle. Both short-term (Duffin, Murphy, and Johnson, 2008) and long-term research (Beane, 1981) has documented the benefits of service learning. In the Duffin study, projects that had a service learning component anchored in the needs of the community were compared to activity-based projects without such a focus, with greater environmental improvements found in the service learning focused projects. The Beane study compared adults who attended a high school where random assignment 30 years ago gave some a course with service learning and others a more traditional academic course. Throughout their adult lives, the students with a base in service learning went on to significantly more (and higher levels of) community involvement.

In sum, a triad of place-based education, augmented reality, and service learning creates a powerful new paradigm of education, leveraging emerging technologies to foster student collaboration while building on proven educational approaches.

What is clear, however, is that this approach cannot just happen. Research to date (e.g. Coulter, 2010) shows that certain teacher attributes are needed for effective program leadership, including a strong understanding of relevant content, comfort with data and model based reasoning, ability to guide students in exploring questions, and personal curiosity and passion to learn more. While each teacher will vary somewhat in these attributes, it is abundantly clear that teachers need some capacity in these areas – and a willingness to continue growing – for complex program implementation. More generally, work undertaken by the Garden/MIT collaboration is developing a theoretical model further articulating the capacities teachers need to lead effective, AR-enhanced projects. A certain level of personal agency is required, built on the teacher's growing pedagogic vision and skill, capacity to forge partnerships within the school and community, and ability to make optimal use of emerging technologies and other resources. This model and a proposed teacher growth trajectory will be shared as part of the symposium.

## **Changing Social Dynamics in Learning with AR Game Authorship**

As an increasing number of youth bring mobile media devices to school with them, educators are wrestling with whether to encourage their use, integrate them into instruction, or ban them entirely (Klopfer, 2008; Squire, 2009). As Roschelle and Pea (2002) argue, the sheer presence of broadband enabled, mobile multi-media computers that users can tailor according to their own interests (downloading audio, video, text or interactive media) and that they can consume with privacy raises questions about how to maintain a central focus to learning activities while also support learners in pursuing their own trajectories. Indeed, with constant access to information and social networks, mobile media challenge our very notions of place, as participants' attention can be divided among classrooms, online forums, and their own media. Learning is amplified through mobile media, as participants extend their interest in new areas, participation in social networks, and experience increased power to influence the world.

Over the last two years, the Augmented Reality and Interactive Storytelling Group at the University of Wisconsin-Madison (ARIS) has been investigating how to create a platform for educators to design mobile learning experiences that leverage these capacities. As an outgrowth of the MIT Augmented Reality team led by Klopfer (2008), it seeks to provide ordinary people tools to author mobile media enabled learning experiences. These range from students designing games about social issues in their neighborhoods to informal science educators creating interactive games about watersheds or forests.

Early research has shown that using smartphones as tools for media creation and AR game authorship can have a transformative effect on students' learning experiences. In this symposium, we will examine claims stemming from a formative case study in which 12 at-risk youth designed mobile media learning experiences about their neighborhoods using the ARIS software platform and other tools. The design work occurred as part of a semester long local games course which, based on the studio model, integrated ecology, citizenship, social history, and media production within one course. Students' design work leveraged a variety of tools, including cameras, applications downloaded from iTunes, and ARIS, the platform used for publishing these games. Each student had access to mobile media devices such as iPhones with full data services for the duration of the course. Researchers observed home, school, and work interactions, collected and analyzed data from time logs, and interviewed parents, students, teachers, and administrators to triangulate findings.

The case study reveals challenges and opportunities for using mobile media within a design workshop, including these four claims:

- 1) Mobile media devices caused few, if any disruptions in students' home, work, or school lives, and instead, amplified interest, success, and capability for participants in these three spheres. Instructionally, iPhones were useful, although participants most often made use of a variety of tools in context-appropriate ways. Specialized tools such as high-resolution cameras, digital audio recorders, and phones were deployed.

- 2) Scaffolding local game design through playing games, structured design exercises, and open-ended collaborative design succeeded in engaging youth, teaching particular design practices and enacting their identities as designers. The first classroom sessions were marked by confusion, as students struggled with the basics of game design and how to take ownership over the experience.

- 3) Curricula that fully integrate mobile media reduce the physical and social barriers to the classroom, enabling participants to more fully engage in civic planning, science, or media design. Participants were constantly in and out of the classroom as they collected physical data, interviewed stakeholders, analyzed the world and used the classroom for conducting meetings, analyzing documents, and producing media.

- 4) Producing local games about their lives led participants to challenge existing knowledge and beliefs as they were forced to integrate the perspectives of different stakeholders in their games. Participants ended the class with more sophisticated understandings of civic planning and democratic processes, as well as increased self-efficacy in citizenship.

## Strategies to Assess Learning in Place-Based AR games

Assessing learning outcomes is crucial to any educational technology intervention, and AR games are no different. The Radford Outdoor Augmented Reality (ROAR) project at Radford University is conducting a proof-of-concept project documenting the feasibility of using augmented reality to effectively teach science to rural middle school students. To show this feasibility, the team needs to assess learning that happens as part of student experiences with AR, and show that it is on par with or better than learning that takes place through other instructional methods.

Radford University is developing and studying elementary, middle, and high school curricula that use augmented reality to create mobile games requiring critical thinking, communication, and collaborative problem solving skills. The story-based, mobile AR games developed by the ROAR team are played on handheld computers. The student players work collaboratively on problem solving challenges based on narrative, navigation, and collaboration cues. (Dunleavy, Dede, & Mitchell, 2009; Klopfer, 2008; Squire & Jan, 2007).

While many areas of AR assessment overlap with other computer-based learning fields, there are specific assessment opportunities and challenges presented to researchers and evaluators (Dunleavy & Simmons, 2011). There are three particular areas related to AR learning, which provide unique assessment opportunities: 1. Identity; 2. Collaborative problem solving and knowledge building; and 3. Data collection and analysis patterns. In addition, the outdoor, dispersed, social and physical nature of AR learning presents unique qualitative data collection challenges.

Role-based AR learning environments provide unique opportunities to assess identity and domain-specific self-efficacy. For example, in an epidemiology game designed by the ROAR team, the students were assigned roles (i.e., entomologist, zoologist, botanist), which required them to collect relevant digital flora and fauna specimens from their school grounds to create an antidote for a deadly disease. Depending upon his or her role, each student saw and interacted with unique and incomplete pieces of data, which needed to be interpreted and combined with his or her teammates' data to gain a full understanding of the problem. Due to the role-based design, each student had a specific area of specialty adding unique value to the team. The use of scientifically based roles is a direct attempt to cultivate a sense of projective identity that could serve as a mediation between the students' real world identity and their game identity (Gee, 2003). In other words, if a student adopts the role of a scientist in a game and finds the role-based activities satisfying and self-affirming, their game-identity could theoretically influence their real-world identity and their related self-efficacy. Although domain-specific self-efficacy has been researched within the virtual gaming environment (Ketelhut, 2005), this is a relatively emergent field and AR provides a rich assessment opportunity to explore the possible interplay among place, situated learning, and identity.

Most AR learning environments provide a ubiquitous or one-to-one computing environment, which affords evaluators and researchers the opportunity to assess the students' ability to collaboratively problem solve using knowledge building and jigsawing techniques (Scardamalia and Bereiter, 1991; Brown and Campione, 1996). As discussed above, a design strategy used to facilitate collaborative learning (Johnson, Johnson, & Holubec, 1994) is to create interdependent roles, which the students adopt within the AR experience. To successfully navigate the AR learning environment, the teams must work together to share and synthesize their respective pieces of data requiring each member to successfully collect, interpret, and communicate his or her unique information. This is a direct attempt to approximate authentic team-based inquiry and is a design strategy used in role-based video games as well as AR games (Jakobson & Taylor, 2003; Klopfer, 2008; Steinkuehler, 2006).

Continuing the epidemiology example provided above, the students need to individually collect their respective specimens, compare how effective it might be in an antidote relative to their teammates, evaluate the best choices and then make a team decision as to which specimens would be most advantageous within the antidote. Using qualitative methods (e.g., observation and player reports) at each step of this process, researchers can assess the skill of the individual student and the larger team based upon their performance on specific observed tasks as well as their overall performance during the experience.

Related to collaborative problem solving is the opportunity to assess the process, logic and pattern of data collection and analysis within AR games. As each student uses a GPS-enabled handheld within the experience, researchers are able to incorporate log files, which can record the students' physical movement and the length of time spent at each location. In addition, these log files can also record responses to embedded assessments, handheld communication, Internet research activity (e.g., websites visited, duration of visit), access to hint screens or tutorials, and other data points. This log file data could provide researchers with a 'cognitive audit trail' for a more thorough analysis of game play and learning than could be accomplished outside of an AR environment (Dunleavy and Simmons, 2011; Montola, Stenros, & Waern, 2009; Dede, 2009).

In addition to the assessment opportunities found within specific areas of learning, AR also provides more general methodological assessment challenges (Dunleavy and Simmons, 2011). For example, the outdoor, dispersed, social and physical nature of AR learning makes observations more complex than a typical classroom observation. During a typical AR implementation, there are approximately ten student teams of three members

each spread out over a physical area the size of a football field. Through trial and error, the research team concluded that shadowing groups of students using a given sampling technique (i.e., maximum variation, convenience) while holding a clipboard to fill out an observation protocol was difficult and problematic. The most significant challenge was the inability of the written observation protocol to accurately document the complexity, nuance, and totality of all the various interactions the students experienced during an AR game. The solution was to shadow as many teams as possible with mobile video cameras to capture the interactions. These videos were then coded and analyzed to reveal any patterns in behavior and movement directly related to the research questions (Dunleavy and Simmons, 2011).

While emerging technologies such as AR will continue to present researchers with unique assessment environments, the lack of valid and reliable instruments aligned with collaborative problem solving and scientific inquiry poses a greater challenge to the implementation of serious, inquiry-based gaming tools such as AR (Dede, 2009). This challenge needs to be addressed by policy makers at the federal, state, and district level as well as academics if augmented reality and other emerging tools are going to be meaningfully adopted by professional educators.

## Speaker Biographies

*Eric Klopfer, moderator*, is the Director of the MIT Scheller Teacher Education Program and the Scheller Career Development Professor of Science Education and Educational Technology at MIT. The Scheller Teacher Education Program prepares MIT undergraduates to become math and science teachers. Klopfer's research focuses on the development and use of computer games and simulations for building understanding of science and complex systems. His research explores simulations and games on desktop computers as well as handhelds. On handhelds, Klopfer's work includes Participatory Simulations, which embed users inside of complex systems, and Augmented Reality simulations, which create a hybrid virtual/real space for exploring intricate scenarios in real time.

He is the co-director of The Education Arcade, which is advancing the development and use of games in K-12 education. Klopfer's work combines the construction of new software tools with research and development of new pedagogical supports that support the use of these tools in the classroom. He is the author of "Augmented Learning", on the research and design of mobile educational games (Klopfer, 2008).

*Bob Coulter* is the director of the Litzinger Road Ecology Center, managed by the Missouri Botanical Garden, and PI / PD for two NSF-funded research and development projects focusing on linking teachers and students to their community through place-based education, augmented reality technology, and service learning. He has also published and presented extensively on educational applications of geospatial technologies, and is a lead member of the Place-based Education Evaluation Collaborative. Prior to this work, he was an award-winning elementary school teacher in public and private schools for 12 years.

*Matt Dunleavy* is an Assistant Professor in Instructional Technology at Radford University in Virginia. From 2006 to 2007, he was a postdoctoral fellow in learning technologies at the Harvard Graduate School of Education and the director of the Handheld Augmented Reality Project (HARP). Dr. Dunleavy received his Ph.D. in Educational Research, Statistics, and Evaluation at the University of Virginia, where he focused on the impact of ubiquitous computing on student learning and the classroom environment. Prior to completing his formal education, he lived overseas teaching English as a Second Language in Cameroon, Central Africa as a Peace Corps volunteer and then independently in Taiwan, Republic of China. He is currently the principal investigator on a National Science Foundation grant and a Virginia Department of Education grant (<http://gameslab.radford.edu/>), both of which explore how mobile technology and augmented reality can be used to improve academic and socio-cultural skills for K-16 school students.

*R. Benjamin Shapiro* is a Postdoctoral Research Associate of the Morgridge Institute for Research at the University of Wisconsin, Madison. He specializes in the design of technologies to make schools more interesting, challenging, fun, and caring, and the study of processes through which technologies are adapted to fit local contexts.

He is currently leading the design, development, and study of educational video games to teach about, and engage the public in, cutting-edge science, including biomedical imaging, ecological conservation, and stem cell biology. One such game will teach about anatomy and cancer by enabling a crowdsourced public to assist doctors in making more accurate cancer diagnoses from CT scans and MRIs.

He has previously designed a range of social and educational technologies, including pioneering mobile tools for finding nearby places, events, and friends, socially networked collaboration and assessment tools used to mentor urban youth into artistic and journalistic communities, data visualizations to help teachers to understand students' thinking, and agent-based computational modeling tools to assist children and scientists alike in studying and understanding complex, emergent scientific phenomena.

Ben received his PhD in the Learning Sciences from Northwestern University, and has a BA from University of California, San Diego, where he studied Computer Science and Cognitive Science.



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# Collaboration as Scaffolding: Learning Together with Dynamic, Interactive Scientific Visualizations and Computer Models

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[All presenters are indicated in the individual posters.]

**Abstract:** Modern technology not only greatly expands the variety of media available for science learning (e.g., dynamic computer visualizations, interactive simulations, computer-based modeling environments), but also significantly enhances opportunities for supporting collaborative learning. The studies in this symposium examine collaboration as a scaffolding strategy in science classrooms that use technology-enhanced visualizations to aid student learning. Together, they consider various forms of collaboration, including co-construction, critique, discussion forums, knowledge distribution, and peer instruction in technology-enhanced learning environments. This interactive poster session will engage presenters and participants in a conversation that explores the following questions: What opportunities exist for different forms of collaboration in science learning environments that employ interactive visualizations? How can we best design technology-enhanced science visualizations to foster collaborative learning? How can we harness the power of interactive visualizations to enhance the effectiveness of collaborative learning? What are the affordances and constraints of different forms of technology-enhanced collaboration for students trying to understand complex scientific topics?

## Introduction

This interactive poster symposium explores science learning at the intersection of visualization and collaboration. Scientific visualizations are not only essential to the work of scientists; using dynamic, interactive computer-based visualizations offers many advantages to support students' learning of science as well. Abstract science concepts are made visible through multi-media representations (Ainsworth, 1999; Linn, Clark, & Slotta, 2003); correlations among multiple variables in a complex system can be simulated through computer models (Wilensky, 2008; Wu, 2010); nuanced, dynamic science processes can be carefully examined through manipulative features (Wieman, Adams, & Perkins, 2008), and the interactivity of computer visualizations scaffolds student-directed learning (Quintana, Zhang, & Krajcik, 2005).

However, the open-endedness that computer visualizations afford, as well as the complex dynamics between learner-computer, learner-learner, and learner-teacher interactions, introduce challenges to educators and designers of technology-enhanced science visualizations. One challenge is to understand the *role of collaboration* in learning environments equipped with dynamic visualizations and computer models. Collaboration has become a standard practice in frontier scientific research and development (Rhoten & Parker, 2004). Incorporating scientific visualizations into innovative learning environments offers opportunities for various forms of collaboration, which can also be viewed as scaffolds to help students take advantage of complex visualizations. For instance, students can work together to control the pace and direction of a visualization, or to set parameters that influence what will appear on the display (Betrancourt, 2005; Hegarty, 2005; Tversky et al., 2002).

## Purpose and Objectives

This symposium is organized to provide a platform for participants to discuss how collaboration as a scaffolding mechanism can strengthen the use of computerized visualizations to promote students' inquiry in science learning. Although collaborative learning has become a popular element in technology-enhanced learning environments in science education, many questions remain unanswered as to how various forms of collaboration can be best combined with the learning opportunities offered by dynamic science visualizations (Lei & Shen, this symposium). Therefore, this interactive symposium invites presenters and the audience to engage in a dialogue that addresses the following questions: How have various forms of collaboration been designed and enacted in science learning environments that employ interactive visualizations? What are the affordances and

constraints of different forms of technology-enhanced collaboration for students trying to understand complex scientific visualizations? How can we best design technology-enhanced science visualizations to foster collaborative learning? How can we harness the power of interactive visualizations to enhance the effectiveness of collaborative learning?

To initiate an response to these questions, this symposium gathers studies that employ different forms of collaboration as scaffolding to support students in learning with interactive dynamic visualizations, including co-construction, critique, discussion forums, knowledge distribution, and peer instruction. Students may co-construct computer models to explore scientific phenomena or solve complex problems (Wu, 2010; Zhang, et al., this symposium; Xie, this symposium), critique each other's work to establish criteria for evaluating visualizations (Hsieh & Chang, this symposium; Schwendimann, this symposium; Shen, 2010), contribute to online discussions with their classmates on evidence related to a particular visualization (Clark, D'Angelo, & Menekse, 2009), and work in pairs or small groups to solve everyday relevant problems while developing inquiry and metacognitive skills (Chiu, this symposium; Linn, 2006; Matuk & King Chen, this symposium). These various collaborative opportunities in visualization-rich learning environments have been designed to help students to develop the skills and mindsets necessary to succeed in today's technology-enhanced world.

In sum, this symposium will provide opportunities for the CSSL community to further our understanding of collaboration as a scaffolding strategy to enhance students' learning through visualizations in science.

## Session Structure and Participating Presentations

The session is planned as an interactive poster session, chaired by Dr. Marcia Linn from the University of California, Berkeley. The session will proceed as follows. Dr. Linn will briefly introduce the session (~5m). Presenters from each study will then summarize their own research in one minute (~10m). Attendees will then circulate and interact with individual presenters (~50m). When applicable, presenters will bring computer-based demonstrations of the technologies used in their research. After the interaction between the presenters (as panelists) and the attendees, the discussant, Dr. Hsin-Kai Wu from the National Taiwan Normal University, will comment on the presentations (~10m) and moderate a conversation that allows presenters and attendees to share their insights (~15m). The following section summarizes the individual presentations for this symposium. The first six posters are based on empirical studies and the last two combined posters report results of comprehensive synthesis reviews.

### Poster1: Student Collaboration to Generate Scientific Principles during Online Peer Critique Versus Direct Feedback Activities

Fang-Pei Hsieh and Hsin-Yi Chang, National Kaohsiung Normal University, Taiwan

We used a week-long Web-based Inquiry Science Environment [WISE] (Linn, 2006) curriculum, *Thermodynamics: Probing Your Surroundings* (Clark & Sampson, 2007) to engage 71 7th grade students in Taiwan in learning heat and temperature. We incorporated an *online peer critique* activity at the end of the *Thermodynamics* curriculum to promote students to collaboratively generate scientific principles of heat and temperature phenomena from their learning with computer visualizations in the curriculum that depict the observable phenomena and underlying mechanism of thermal conductivity and equilibrium. In another version of the *Thermodynamics* curriculum we replaced the *online peer critique* activity with an *online direct feedback* activity in which students were guided to respond to conceptual questions and receive direct feedback from the computer on their responses in light of the correctness. The conceptual questions targeted students' concepts of heat and temperature necessary for students to generate the scientific principle. The design of the *online direct feedback* activity is based on conventional instruction practices in which teachers formatively assess students' content knowledge and provide feedback on the correctness when students show alternative conceptions. In comparison, the use of *online peer critique* activity is based on research calling for collaborative learning in science classrooms (NRC, 2007) and on empirical studies showing the benefits of critique or reflective activities for promoting integrated understanding (Chang, Quintana and Krajcik, 2010; Linn, Chang, Chiu, Zhang & McElhaney, 2010; White and Frederiksen, 1998).

Two classes of 7th-grade students taught by the same science teacher at a public junior high school in South Taiwan were randomly assigned to either the online peer critique or direct feedback condition. In both conditions each dyad of students worked collaboratively in front of a desktop computer. In the online critique condition student dyads were guided to critique scientific principles of thermal conductivity and equilibrium made and posted by other dyads through the online discussion forum in the curriculum. In the direct feedback condition, after generating their scientific principle, student dyads were guided to respond to multiple-choice questions on related concepts and receive feedback. After either the critique or feedback activity the curriculum in both conditions guided students to revisit and revise their scientific principles. Data collected include pre-post tests, video recordings of student actions and discussions, and students' digital critiques or responses. We

analyzed and compared collaboration promoted by the online critique versus direct feedback activities. Initial results indicated that students in both conditions performed equally well on the pre-post tests. Moreover, results from process videos indicated different dynamics, scales and uses of resources during student collaboration within and across the online critique and direct feedback activities. The collaboration in the *online peer critique* group involved larger scales of participants and resources but also more confusions and uncertainties than the collaboration in the *online direct feedback* group.

## **Poster2: The WISE Idea Manager: A Tool to Scaffold the Collaborative Construction of Evidence-Based Explanations from Dynamic Scientific Visualizations**

Camillia Matuk and Jennifer King Chen, University of California, Berkeley

Collaboratively constructed explanations not only help students connect claims with evidence; they can also promote productive argumentation in scientific inquiry (Bell, 2004; Suthers & Hundhausen, 2001). However, this can be challenging with topics that require learners to select, manage, and integrate multiple pieces of evidence from various sources. In this poster, we present the Idea Manager, an innovative tool to help students construct coherent explanations of complex scientific phenomena. In particular, we illustrate its use in Investigating Planetary Motion and Seasons, an online curriculum that guides students' inquiry into the causes of the seasons.

Individuals of all ages struggle to correctly explain why seasons occur (e.g., Baxter, 1989; Schneps & Sadler, 1994; Atwood & Atwood, 1996). Most mistakenly attribute seasonal variations in temperature to changes in the distance between the Earth and the Sun (e.g., Bakas & Mikropoulos, 2003). This is not surprising, since the correct explanation for the seasons – that the Earth's tilt causes changes in the intensity of sunlight – is not immediately apparent from students' personal experiences. Moreover, negotiating a coherent, shared explanation requires students to coordinate various direct and indirect observations from multiple sources, and to critically evaluate and use these as scientific evidence.

Investigating Planetary Motion and Seasons, a technology-enhanced high school curriculum unit designed with the WISE platform (Slotta & Linn, 2009), addresses these issues by: (1) Providing interactive visualizations for students to investigate seasons through inquiry and experimentation, and (2) Scaffolding students' learning from these visualizations with the Idea Manager. The latter provides a space in which student partners can record their developing ideas; and tools to promote their critical selection of evidence, strategic organization of information, and construction of coherent, evidence-based explanations. Customizable annotation, tagging, and flagging features prompt students to justify their interactions with the visualizations, to articulate their interpretations of the outcomes, and to make explicit connections between the evidence gathered and different possible explanations for the seasons. Finally, activities with the Idea Manager are designed such that students must negotiate all decisions with partners. Thus, they provide multiple opportunities for students to collaboratively build upon their own and others' ideas toward more normative understandings.

By elaborating on the principles behind the design and integration of the Idea Manager into an online science inquiry unit on the seasons, we consider how the design of technological tools can support students' collaborative sense-making of complex phenomena, and ultimately impact their learning.

## **Poster3: Investigating the Role of Collaboration on Monitoring Understanding with Dynamic Visualizations**

Jennifer Chiu, University of Virginia

This study explores how collaboration can help learners monitor their understanding of dynamic visualizations. Although research demonstrates the overall benefit of dynamic visualizations on learning (Hoffler & Leutner, 2007) various studies with animations or dynamic visualizations compared to static representations produce mixed results. In particular, dynamic visualizations that enable learners to control information delivery, manipulate parameters or content, or rotate objects in a screen can facilitate complex understanding and reasoning (Stieff & Wilensky, 2003). However, this kind of interactivity can also present challenges to learners. Learners need to have appropriate self-monitoring skills to know when to stop, restart, or manipulate variables to remedy gaps in understanding (Zahn, Barquero & Schwan, 2004). Learners can be distracted by perceptually salient aspects of visualizations, fail to focus on conceptually relevant aspects, or neglect to investigate the visualization as a whole (Lowe, 2004). Research suggests that training learners in self-monitoring strategies can improve conceptual understanding in hypermedia environments (Azevedo & Cromley, 2004). However, most existing studies use individual subjects and there is very little research focusing on the role of collaborative learning with dynamic visualizations, especially regarding monitoring (Ainsworth, 2008).

This poster explores how collaboration can benefit learning with dynamic visualizations by encouraging learners to collectively monitor their understanding. This poster explores how high school students collaboratively monitor their understanding using dynamic molecular visualizations of chemical reactions.

Students worked in pairs on a week-long computer-based inquiry chemistry unit that featured dynamic visualizations embedded within instruction that encouraged knowledge integration (Linn & Eylon, 2006). Analysis of videotapes and embedded data from the computer-based environment revealed that students working in pairs helped each other notice and focus upon different parts of visualizations, encouraged each other to revisit the visualization to either confirm or rectify misunderstandings, encouraged each other to explain concepts to one another, and spurred each other to interact with the visualizations by changing different parameters or content. This poster offers insights into how collaboration can help students use dynamic visualizations more effectively.

#### **Poster4: Learning Evolution through Collaborative Critique-focused Concept Mapping**

Beat A. Schwendimann, University of California, Berkeley, Beat.schwendimann@gmail.com

The theory of evolution is a unifying theory of modern biology, and notoriously difficult for students to understand (Alters & Nelson, 2002; Bishop & Anderson, 1990). Many students continue to use 'need' instead of 'mutation' to explain evolutionary change, even after years of instruction (Shtulman, 2006; Southerland, Abrams, Cummins & Anzelmo, 2001). This study hypothesizes that the continued use of the concept 'need' is sustained by a disconnection between phenotype-level and genotype-level concepts. The relationships between phenotype and genotype concepts are fundamental to the understanding of heredity and development of organisms (Mayr, 1988). Making these connections visually explicit may help students build a more coherent understanding of evolution. A week-long technology-enhanced curriculum on human lactose tolerance, *Gene Pool Explorer*, was developed and implemented in four 9<sup>th</sup> grade biology high school classes (n=96). The project includes scaffolded inquiry-based dynamic population genetics visualizations and two collaborative concept-mapping activities to explore the connections between genotype and phenotype concepts.

This study investigates how student dyads learn from an inquiry-based evolution curriculum by either co-constructing concept maps or co-critiquing concept maps. Traditionally, students generate concept maps from scratch, which can be time-consuming and challenging, especially for students with low prior knowledge (Schwendimann, 2008). As an alternative, students receive pre-made concept maps that include commonly found alternative ideas. Concept maps in both treatment groups (*generation* and *critique*) consisted of the same concepts and had a drawing area divided into the domain-specific areas of genotype and phenotype to make connections within and across areas explicit. Students had to generate their own criteria to critique the maps and negotiate with their partner on how to revise the map. Pretest and posttest essay items were scored using a five-level knowledge integration rubric (Linn, Lee, Tinker, Husic & Chiu, 2006). Concept maps were scored on a propositional level using the knowledge integration concept map rubric (Schwendimann, 2008) and on a network level.

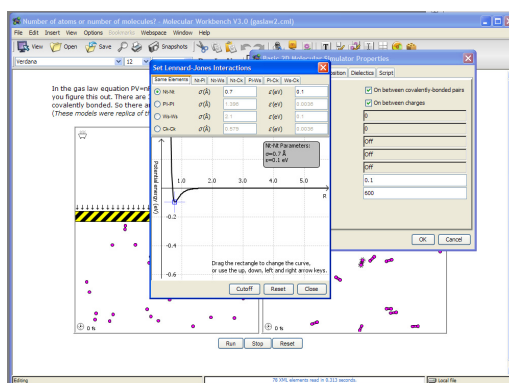
Students in both treatment groups gained significantly from pretest to posttest. Students in the critique group used the alternative idea 'need' significantly fewer times in their posttest answers than the generation group. Students with low and medium pretest knowledge in the critique group improved their overall posttest concept map score more than students in the generation group. Students in both treatment groups created significantly more cross-connections between phenotype and genotype concepts in the posttest map. Students in both groups created significantly more links to the concept 'mutation' in the posttest concept map than in the pretest map, with the critique group showing larger gains. Findings indicate that the curriculum *Gene Pool Explorer* helped students make connections between genotype and phenotype concepts explicit. The concept 'mutation' became more connected, while the alternative idea 'need' was used fewer times. Findings suggest that collaborative concept map critique activities can be a beneficial alternative to generating concept maps, in particular for students with low pretest knowledge. The findings from this study can be valuable for informing the design of effective collaborative learning environments to support a more integrated understanding of evolutionary biology.

#### **Poster5: Collaborative Problem-solving with the Molecular Workbench**

Charles Xie, Concord Consortium

Learning can be enhanced when students are challenged to collaboratively design simulations that answer a question or solve a problem. We conducted a pilot study that addresses collaborative learning in conjunction with problem-based (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Hmelo-Silver, 2004), challenge-based (Apple, 2008), or project-based learning (Krajcik & Blumenfeld, 2006; Polman, 2000). We have built a number of supporting mechanisms into our Molecular Workbench software (<http://mw.concord.org>), a cyberlearning tool used to teach a wide variety of science concepts using interactive simulations. These mechanisms include 1) a web service that allows students to work on the same activity side by side and create a joint report for the teacher; 2) a web service that allows students in a class to see one another's creations; 3) an easy way to download and revise any public simulations; 4) an easy way to publish students' own simulations.

Our pilot studies show that students can come up with surprisingly creative solutions to complex problems. The collaborative mechanisms played an important role in students' intellectual processes. For example, one student specifically commented: “[the Molecular Workbench] allowed me to explore in a way unimaginable before when I built a fuel cell simulation step by step myself. I could let my curiosity flow by exploring how each editing tool affected my creation. I could also see other simulations built by students from around the world. Thus, I was able to learn in two ways—by attempting my own experiment and by analyzing other simulations.”



**Figure 1.** Screenshot of Molecular Workbench: High School and College Students Can Design Virtual Experiments about Gas Laws and Share Them with Others and Collaboratively Evolve Their Ideas.

It is important to note that while students shared their work with others and were inspired by others' work, we found no evidence that they would just copy one another's simulation or duplicate an existing simulation from the Internet. While collaborating on constructing simulations, students worked together to iterate through many steps of trial-and-error. Our pilot study suggests a pedagogical model that can be broadly useful in developing effective instructional strategies involving interactive, visual simulations. Our future work is to identify more specifically the cognitive mechanisms involved in collaborative modeling, such as the collective intelligence factor (Woolley et al., 2010).

### **Poster6: Developing A Web-based Modeling and Visualization Technology Integrated Inquiry-based Science Learning (WiMVT) Environment for CSCL**

Baohui Zhang, Daner Sun, Karel Mous, and Quee Boon Koh, Learning Sciences Lab, National Institute of Education, Nanyang Technological University, Singapore

It has been challenging to allow K-12 students to be engaged in authentic scientific practices such as modeling, visualization, and collaborative inquiry to facilitate meaningful learning. Over about five years of intensive school-based studies following a design research tradition, a group of researchers in Singapore have distilled their intervention in their pedagogical design as an iMVT (Modeling and Visualization Technology Integrated inquiry-based Science Learning approach) that applies to science learning in general (Zhang, Ye, Foong, & Chia, 2010). The pedagogy was substantiated by a series of curriculum features when integrating inquiry skills, such as asking questions, designing investigations, collecting data, analyzing data and making conclusions, in modeling and visualization practices. In order to sustain and scale up the innovation, we are developing a web-based iMVT system called WiMVT to integrate useful curriculum features systematically.

Innovative learning environments need to support individual as well as collaborative learning (Kreijns, Kirschner, & Jochems, 2003; Stahl, Koschmann, & Suthers, 2006). In addition to features that support iMVT practices (e.g., *simulate*, *validate*), the WiMVT system also includes social technologies such as the *synchronized chat* function and *real time collaborative modeling* feature. The *real time collaborative modeling* feature is a unique component through concurrent interactions among group members and can be reviewed by teachers and group members publicly (Figure 2a,b). The iMVT framework, user-centered, and simultaneous construction of models as CSCL are among a series of design principles. This real time collaboration environment is realized through shared workspace which is a commonly used means for synchronous collaboration (Gutwin & Greenberg, 2002). Other concurrent communicative tools such as a *chat* dialog and *group comment* box are provided for students to exchange ideas and learn together through examining different points of view in their modeling process (Marttunen & Laurinen, 2007). Meanwhile students get quick feedback from their group members or teachers through these tools. To accommodate more students with varied cognitive abilities, progressive modeling approach is integrated for students to master the gradual transition from qualitative modeling to quantitative modeling. The features of collaborative modeling provides students with

different cognitive abilities and flexibility to co-construct a model that allows the elaboration and negotiation of diverged thinking to converge and approximate that of experts (Wu, 2010; Zhang, et al., 2006).

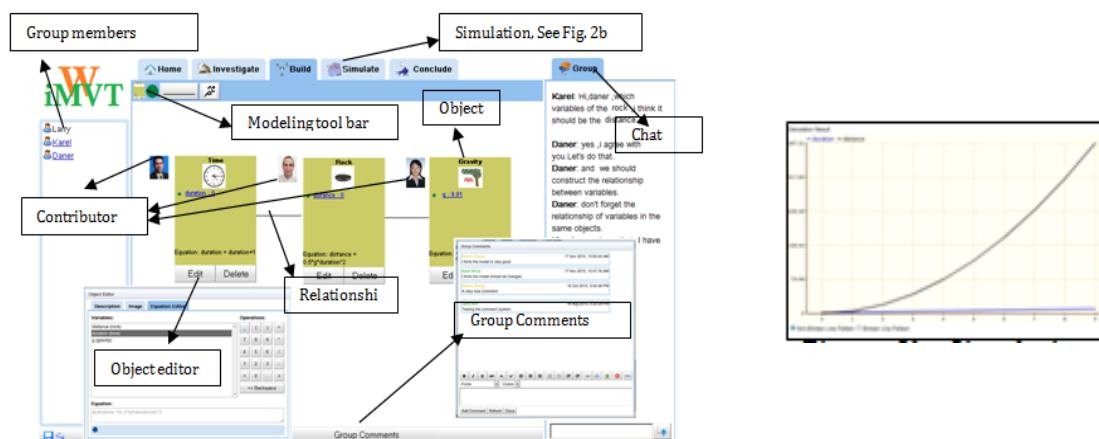


Figure 2 (a). The Collaborative Modeling Core Feature of the WiMVT System; (b) Simulation Interface.

The WiMVT system is currently capable of concept visualization through collaborative quantitative modeling. The remaining learning management features that further facilitate collaborative inquiry are still under development. The current system still allows inquiry to be done by using the simplified inquiry process “investigate, build, simulate and conclude” and supplementary curriculum materials. Usability tests have been done when pairs of volunteers co-construct quantitative models. The research report of usability tests is based on process videos, surveys, and participants’ debriefing interviews. The tests help to improve the existing design and show direction on the development.

### Poster7&8: Collaboration in Technology-enhanced, Modeling-based Instruction (TMBI) Environments in Science Education

Jing Lei, Heng Luo, Sunghye Lee, Syracuse University [Part I]

Ji Shen, Bahadir Namdar, Rutchelle Enriquez, University of Georgia [Part II]

Well-designed technology-enhanced, modeling-based instruction (TMBI) environments can help students not only learn science knowledge, but also develop modeling skills and metacognitive habits of mind (Stratford, Krajcik, & Soloway, 1998; White, 1993). TMBI helps amplify the power of traditional model by providing new representational system (Dimitracopoulou & Komins, 2005). Many computer-based modeling environments for K-12 science instruction have been developed over the last two decades (Linn & Hsi, 2000; Stratford, 1997; Wieman, Adams, & Perkins, 2008), such as *Model-it*, *MolecularWorkbench*, *NetLogo*, *PhET*, and *Wise*. These TMBI environments often support peer collaboration and interactive computer visualization (e.g., Linn, Clark, & Slotta, 2003).

Collaboration is critical in MBI because students need to be engaged in socially mediated construction of science knowledge, and social interactions can help students develop, negotiate, and revise their models about science concepts (Komis, Ergazaki & Zogza, 2007, Penner, 2001). In practice, students often work in various collaborative formats in these innovative learning environments to share resources or strengthen modeling practices (Barnea & Dori, 1999; Linn et al., 2006). However, although collaboration is often embedded in TMBI environments, little research has been conducted to examine how collaboration occurs during the modeling process and how it can be facilitated by computer technology. Moreover, the role of collaboration in a TMBI environment in terms of individual student learning outcome is contested: e.g., students may see collaboration as an opportunity to reduce workload (Barab et al., 2000); students get less opportunity to manipulate the technology (Metcalf & Tinker, 2004). We address these questions in two related literature synthesis studies. With different foci, both studies review and synthesize empirical studies on TMBI in K-12 science education that were published during 1980 to 2010.

#### Part 1—Collaboration and Technology Design

This synthesis study aims to examine what and how technology can facilitate student collaboration during model development. Specifically, we focus on three research questions: (1) What technology tools are effective in supporting collaboration in MBI learning environments? What are their key design features? (2) What types of collaboration are supported by computer technologies? And (3) What are the instructional strategies to facilitate technology-supported collaboration in MBI? Our preliminary findings suggest:

- Most technology tools used in MBI science learning environments are software-based applications that enable science model construction through simulation or programming, and Internet is often integrated to support student's modeling activities and collaboration. The key design features that support collaboration include: allowing students to simultaneously work on the same task, making thinking process visible for peers and instructors, emphasizing norms of discourse to facilitate discussion, providing immediate feedback to construct coherent conversation, and creating a low-stress environment for collaboration.
- Collaboration in classroom settings among small groups is the most common type supported by computer technologies. Tele-collaboration is also supported by web technology to engage students in communicating and collaborating with peers at distance on science modeling building. Major collaborative learning activities include: students with different expertise work as a team and teach each other; students discuss or debate over complex phenomena or confront misconceptions; students share, evaluate or critique each others' ideas or models.
- The effective strategies to facilitate technology-supported collaboration in MBI include: use technology to engage students in authentic project-based or inquiry-based learning so that students are more likely to work together in or outside class; direct students to specialize in different topics so that they can teach each other and develop explaining skills; highlight differences in models' behavior (between different groups, between exhibited and desired, or between different sites) and encourage students to confront such discrepancy through discussion and debate.

## Part 2—Collaboration and Student Learning

This synthesis study examines the role of collaborative learning on students' learning outcome in TMBI. We describe how different types of collaboration in a TMBI environment can help students learn science concepts more effectively. We provide taxonomy of collaborative formats and modeling skills based on existing literature about collaboration, use of technology in the science classrooms, and modeling opportunities for students. We present affordances and constraints of such collaborative formats. The major findings, among others, include:

- Classroom collaboration has different levels. Individual, local, and public spaces are often intertwined when students discuss and negotiate how to build the best model (Barab et al., 2000).
- Co-constructed model can be a "reified object" of which students generate collaborative discussion to further their learning (Penner, 2001; Hogan & Thomas, 2001). Comparing to a physical object, typically, a computerized model has several advantages in enhancing students' learning (e.g., portability, interactivity, and transformability).
- Argumentation in these collaborative settings can help students come up with better models and in-depth understanding (Ergazaki et al., 2005; Fazio et al., 2008; Sins et al., 2005).
- When modeling complex phenomena with multiple variables, students working in pairs or small groups may help each other to start to make sense of the interconnected variables (Hogan & Thomas, 2001; Wu, 2010;).
- Benefits notwithstanding, collaboration rarely enters the equation of outcome measurement. This may be because there is no well-defined measure of collaborative ability.

We call for innovative ways for researchers to consider new lenses to look through in examining how to measure the increase of understanding of students within or outside collaborative opportunities in TMBI.

## **Concluding Remarks**

The empirical studies in this symposium explore different forms of collaboration in innovative environments that employ dynamic visualizations to support students' understanding of abstract science concepts. Meanwhile, the review studies examine the role of collaboration in TMBI environments, in which computer visualization is a central component. Together, they suggest insights into the roles of collaboration and visualization. Collaboration may enhance the benefits of visualizations by supporting students in integrating science knowledge, explaining scientific phenomena, solving complex problems, and monitoring their understanding. It is of great value to further understand the affordances and constraints associated with different collaborative forms and methods (e.g. co-construction vs. co-critique for students with different prior knowledge) in order to make collaborative learning through visualizations more successful. Furthermore, collaboration that blends local and public levels (e.g., a group of students may evaluate a visualization generated by another group) presents both opportunities as well as challenges in designing visualization-rich learning environments.

This symposium will generate meaningful dialogue and lively interaction among presenters and audience members. It will also be a chance to initiate future research collaborations. Contributions from the audience's multiple perspectives will help further our collective understanding of the roles and mechanisms of collaboration in innovative learning environments and how to best facilitate successful collaboration to help students take advantages of learning with visualizations.



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## Contextualizing the Changing Face of Scaffolding Research: Are We Driving Pedagogical Theory Development or Avoiding it?

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**Abstract** This symposium will discuss how scaffolding research can inform the next generation of highly distributed and technology-rich learning environments. Contemporary technologies offer great potential to complete some of the activities that have been described as scaffolding. However, despite the wide body of research that has investigated the use of technology to scaffold learning, there is a lack of consensus about what the accumulated body of scaffolding research demonstrates, what the term scaffolding should mean and how we might operationalize the concept to meet the challenges posed by modern, diverse technology-rich learning environments and increasingly techno-savvy learners. There is limited research into scaffolding through wireless, mobile, tangible and ubiquitous technologies and insufficient theory development to take forward the principles at the heart of the scaffolding concept. This situation is compounded by lack of learning-centred definitions of context that can add a 'learning sensitive' dimension to the developments in 'context sensitive' computing.

## Background

Research into scaffolding through technology has extended far beyond the adult and child interactions originally studied by Wood and his colleagues (Wood, Burner & Ross, 1976; Wood et al, 1992; Wood & Wood, 1999). For example, empirical studies have been undertaken with learners aged 5–11 years, studying a range of subjects including science and maths (Holmes, 2005; Butler & Lumpe, 2008). Work has also been completed with learners aged 11–18 years studying maths (Koedinger et al, 1997; Beal & Lee, 2008), science (Azevedo et al, 2005; Puntambekar & Stylianou, 2005) and history (Li & Lim, 2008). There have been numerous studies with older learners in college and in higher education, including trainee teachers (Oh & Jonassen, 2007); science students (Chen et al, 1992; Crippen & Earl, 2007; Ge & Land, 2004), and technology students (Tuckman, 2007). Researchers have not restricted themselves to scaffolding domain level concept learning and have also explored the potential for scaffolding to be used to support the development of affect and higher order thinking, such as metacognition (Alevin, et. al., 2004; Harris et al, 2009). Nor have they restricted their research to individuals: groups and the scaffolding of collaboration between learners has also been studied (see for example, Guzdial et al., 1996); Zurita & Nussbaum, 2004).

Research in CSCL has focused on facilitating collaboration by scripting and structuring collaborative interactions among students. Computer-supported scripts directly influence the collaborative dialogue, instead of training students prior to the actual collaboration (Schwarz, Asterhan, & Gil, 2009). For example, students are provided with carefully designed scripts to engage in processes such as argumentative knowledge construction (e.g., Weinberger, Stegmann, Fischer, & Mandl, 2007; Weinberger, Stegmann, & Fischer, 2005), grounding (Schoonenboom, 2008), and so forth in online CSCL environments. Furthermore, Wecker and Fischer (2007) have examined fading the structure by adapting and gradually reducing the specificity of prompts according to the contributions of individual participants, in combination with distributed monitoring and feedback by partners during collaboration.

These examples illustrate the breadth and variety of learners, subject areas, environments and approaches that have been attended to by scaffolding research. They also demonstrate the enormous shift that has taken place in the ways in which researchers interested in using technology to support learning use the term scaffolding. None of these approaches to scaffolding are necessarily mutually exclusive and they are combined within some systems. However, the original focus on the diagnosis of learner need, the provision of assistance

and the fading of that assistance, that were essential to the original conceptualization of scaffolding, are absent from many contemporary software scaffolding applications.

In contrast to the breadth and variety that can be seen in the learners, subject areas, environments and approaches that have been explored as part of scaffolding research, there has not been a great change in the nature of the technology that has been used and most of the scaffolding with technology research has continued to use fairly conventional technologies and has not embraced pervasive, mobile, ubiquitous and tangible technologies. Work such as that conducted by Nussbaum, 2009; and Looi et al., 2009, that uses mobile technologies represents an encouraging exception. Personal, portable, and wirelessly networked technologies are moving us into a new phase in the evolution of technology-enhanced learning (TEL), namely, seamless learning. It forges mobile learning spaces, and the continuity of the learning experiences across different scenarios or contexts (Looi, Seow, Zhang, So, Chen, & Wong, 2010; Frohberg, Göth, & Schwabe, 2009). The application of mobile technologies to the design of learning encompasses facilitating and scaffolding student-centered learning activities in both formal and informal settings. They provide 'context-aware' tools, reference tools, representational tools, analytical tools and communication tools, which serve as distributed resources for learner collaboration activities.

Beyond Scaffolding research there is a growing body of research that uses mobile, ubiquitous, tangible and pervasive technology in novel and interesting ways to support learning. For example, RoomQuake and WallCology (Moher et al, 2005; 2008) in which a range of technologies are used to embed the learners' experiences across a variety of the elements of their physical environment. Research that is exploring the use of tangible and embedded technologies to support learning (Stanton-Fraser, 2007; Marshall et al, 2009 for example) rarely involves scaffolding in the traditional sense, although several researchers have suggested that there may be the potential for such artefacts to scaffold learning (Luckin et al, 2003, O'Malley & Fraser, 2004; Cassell, 2004).

Within both Scaffolding research and research that explores the use of mobile, pervasive, ubiquitous and tangible technology there is a lack of progress with respect to theory development. Useful attempts have been made to organize scaffolding research. Reiser (2004), for example, draws a distinction between software scaffolding approaches that aim to structure the learner's task and those approaches that shape the learner's performance and 'problematize' the task. He envisions the two approaches — structuring and problematizing — working together to scaffold learners. Quintana and colleagues have developed a Scaffolding Design Framework for science inquiry (Quintana et al, 2004; Quintana & Fishman, 2006). The focus is upon the provision of scaffolding support for science inquiry activities and is based upon some key scaffolding processes for science inquiry, it does not however address the problem of fading. Research that explores the use of mobile, pervasive, ubiquitous and tangible technology also suffers from under-theorization about the nature, process, and outcome of learning (Sharples et al., 2005, 2007); a lack of models and frameworks that specify the relationships between learning and tangible technology (Luckin, 2010; Price et al, 2008); and a lack of understanding about the kinds of characteristics learners are expected to possess in terms of nurturing lifelong learning dispositions. In addition, our understanding of the all important concept of *the learner's context* has not been sufficiently developed to produce models that can support a conceptualization of scaffolding that encompasses the breadth of people, places and artefacts with which a learner interacts, that can be connected through technology, and that might be better used to support and scaffold learning.

## The Importance of Context

Previous research, some of which has emanated from research into scaffolding, has confirmed the importance of looking at the *context* of a learner's interactions (Wood, Underwood & Avis, 1999). However, this research has been largely limited to specific environmental locations, such as university lecture halls, school classrooms or 'the workplace'; and it has rarely focused upon teachers as learners. Such an approach limits consideration to just one of the many environments with which and in which a learner interacts. It can also encourage a view of context that conceptualizes it as a container (Cole, 1996), rather than as something that connects our learning experiences together and helps us to make sense of our experiences.

Context is a concept that is discussed across many disciplines and from a variety of perspectives: geography, architecture, anthropology, psychology, education and computer science, for example. It is however possible to identify common themes that transcend these disciplinary boundaries and to arrive at a definition of context that can be used as the basis for exploring learning contexts. Such a definition can support the development of technology-rich learning opportunities that take advantage of the potential afforded by the wide range of evolving ICTs. It can also act as a starting point for the integration of scaffolding across multiple physical and virtual spaces, multiple knowledge domains, multiple time periods and with multiple collaborators. The provision of such a definition is not an easy task, context is a complex concept (Nardi, 1996) and very difficult to 'pin-down' in a way that enables it to be used as the basis for informing design.

Much of the literature about context and space is not specifically about education and learning, and yet it deals with issues, such as institutions and social interaction that are fundamental. Context is portrayed as

complex: a dynamic entity that is associated with connections among people, things, locations and events in a geographic and temporally situated narrative. Discussions that link context to space and place are frequent and we see space portrayed as a container within which people and artefacts can be usefully related to one another; and place as a more immediate entity that is framed by form, function, human interactions, design and legislation; and defined by power, policy and politics (Casey 2001:683 for example). The proliferation of ubiquitous ICT adds to the complexity of discussions of context and supports the integration of concerns with the built environment and with the digital environment, or the blended physical and digital environment: 'The proliferation of the microchip renders the everyday spaces of our existence alive, capable of interacting and reacting to our passage' Kerckhove & Tursi (2009:53). For some context is not a singular entity, but rather a multiplicity to which we are serially exposed. Cummins et al (2007) who suggest that in order to make progress, future research should consider 'individual exposure to multiple "contexts" in time and space'.

From a social sciences perspective, Michael Cole's (1996) text on cultural psychology is particularly helpful with respect to context: a term that he suggests is 'perhaps the most prevalent term used to index the circumstances of behaviour' (Cole, 1996: 132). He distinguishes between 'two principal conceptions of context that divide social scientists' (Cole, 1996: 131): the first conceptualization is as 'that which surrounds'. This way of talking about context separates the activity being studied from the influences surrounding it and is open to the criticism that context is portrayed as a container for an activity or event, rather than context being part of the same situation. The second conceptualization of context discussed by Cole is one that builds on a metaphor of weaving, which requires that we interpret mind in a relational way: 'as distributed in the artifacts which are woven together and which weave together individual human actions in concert with and as part of the permeable, changing, events of life' (Cole, 1996: 136).

This attention to the distribution of mind across connected artefacts in the world is echoed in the situated approaches to cognition and learning (for example, Brown, Collins & Duguid, 1989; Brown, 1990) and the Legitimate Peripheral Participation thesis (Lave, 1988; Lave & Wenger, 1991). Likewise, the work of Vygotsky (1978; 1986), whose socio-cultural approach influenced, amongst others, the work of Cole as discussed earlier, resonates with a conceptualization of context that adheres to the notion of a weaving of mediated experiences. The basic ideas of Vygotsky's approach are presented in the 'general law of cultural development', which makes explicit the link between the external activity of the 'interpsychological' activity of the individual's culture, and the 'intrapyschological' processes within the mind that allows the internalization of the higher mental processes from their social origins. They are also the foundation upon which the notion of scaffolding is built.

## Theories to Support the Further Development of Scaffolding

One way of exploring how scaffolding might be developed in a manner that addresses the need for a 'learning sensitive' dimension to the developments in 'context sensitive' computing, seamless learning and beyond is to develop models of a learner's context that can inform design. Little work has explicitly attempted to model a learner's wider context and the role of technology. Some work within the open learner modelling community has considered lifelong learner modelling (Kay 2009), while some has considered the use of mobile technology to model mobile learning behaviour (Sharples et al. 2007). A broader perspective finds some useful ideas, such as the Locales Framework (Fitzpatrick 2003) from that attempts to capture the complexity of the real world in an abstraction that can be used to support the design of CSCW technology. It is about the workplace rather than education, but it acts as a useful touchstone for modelling the complexity of a learner's context.

The locales framework (Fitzpatrick 2003) was motivated by the author's desire to find a way of understanding the requirements of complex social situations and design software systems to support such situations. The framework is a shared abstraction and a common language for both those who want to understand the complex social world of work and those who want to design technology support. The framework is built on the premise that designing a socially embedded system is a 'wicked problem'. Wicked problems are not clearly defined and nor do they have a definite solution; a 'good enough solution is the realistic goal' (Fitzpatrick 2003). Fitzpatrick suggests that there is a co-evolution of problem definition and solution when wicked problems are involved and when no clear rules for deciding when the solution has been reached. This type of problem is common in social situations, such as learning. The aim of the locales framework is to support both the increased understanding of complex wicked problems and the system design for wicked problem solutions. The work is clearly relevant to the development of technology-rich learning environments. It is also an interesting example of increasingly common situations where taking an interdisciplinary approach is fruitful. Fitzpatrick's work is aimed largely at the CSCW community, yet it possesses clear and useful parallels to education. Fitzpatrick's work is both theoretically grounded in other work from within CSCW and empirically grounded in Fitzpatrick's experience of system design and workplace study. It is based on a metaphor of 'place' in recognition of the way people construct 'places' through their interactions with spaces (also described as sites) and things; the resources (also described as means) through which people achieve their work. The

emphasis of the locales framework is on place and work, nevertheless, this work offers a useful model that might be adapted for a focus on learning and interaction.

Research into mobile learning can also offer some potentially useful work. Sharples et al. (2007) offer an interesting model of context to discuss a theory of mobile learning that encompasses portable technology and the mobility of people as they learn. They suggest that traditional classroom learning is built on the illusion of a stable context. They suggest that mobile learning removes the fixed elements of the learner's situation that allow this classroom illusion, 'creating temporary islands of relatively stable context'. Learning is 'characterized as a process of coming to know through conversation across continually re-constructed contexts' (Sharples et al., 2007: 231). As with many existing mobile learning research (Waycott, Jones, & Scanlon, 2005; Zurita & Nussbaum, 2007; Liaw, Hatala, & Huang, 2010) Sharples et al. ground and conceptualize the application of mobile technologies to learning in the framework of activity theory. Activity theory views learning as a cultural-historical activity system, mediated by tools that both constrain and facilitate the learners in achieving their learning goals (Sharples et al., 2005, 2007). They distinguished two layers of tool-mediated activity: the semiotic layer and the technological layer. The technological layer represents learning as an engagement with physical tools such as computers and mobile devices that function as interactive agents in the process of knowledge construction. Learning is seen as a semiotic system in which the learner's object-oriented actions are mediated by cultural tools and signs (e.g., language and rules). At the semiotic layer, social interaction occurs mediated by the use of technology as representational tools. CSCL happens in the context of interactions and social scaffolding between and amongst mobile learners. Sharples et al.'s model is built on the belief that learning is driven by conversation. They propose that Laurillard's conversational framework can be used more broadly with other age groups and settings. An adapted conversational framework stresses that conversations take place at the level of actions, involving the performance of an activity, and at the level of descriptions, when learners and collaborators talk about their actions to make sense of them. Sharples et al. state that each individual member of such conversations is located in some physical reality and, therefore, in addition to a need for the constant negotiation of the language of communication, there is also a need to constantly negotiate the context of these conversations. To this end, they propose their model of context and learning: the 'activity system of mobile learning'.

The Ecology of Resources approach (Luckin, 2010), builds upon this previous modeling enterprise and offers a learner-centred definition of context that recognizes both the subjective and the objective nature of learner's experiences with the world, the interconnectedness of all the elements with which people interact and the way in which these interactions shape their understanding of the world. In this model, a person's context is made up of the billions of interactions that they have with the resources of the world: other people, artefacts and their environment. These resources provide 'partial descriptions of the world' which help the learner to construct a distributed understanding of the world that is crystallized with respect to a particular individual through a process of internalization. The Ecology of Resources model is offered as an abstraction that represents part of this reality for a learner, an abstraction that can be shared between social and technical researchers and practitioners to support analysis and to generate system design. It is grounded in an interpretation of Vygotsky's Zone of Proximal Development, is concerned with learning and considers the resources with which an individual interacts as potential forms of assistance that can help that individual to learn. These forms of assistance are categorized as being to do with Knowledge and Skills, Tools and People and the Environment. These categories are not fixed, but rather offer a useful way to think about the resources with which a learner may interact and the potential assistance that these resources may offer. The Ecology of Resources model is used as the basis for a design framework that has been and continues to be used to develop technology rich learning experiences with learners and teachers within and outwith formal education.

## The Challenge

The diversity of approaches that have been labeled as scaffolding has led to a variety of opinions and suggestions about how we might best proceed. Some researchers propose that we look at the ways in which different communities have used the scaffolding concept in order to further develop its theoretical foundations (Davis & Miyake, 2004). Others suggest that we need to look back at the origins of scaffolding and, in particular, to Vygotsky's conception of learning (Pea, 2004; Puntambekar & Hübscher, 2005). There is a growing body of opinion that fading is a fundamental and intrinsic component of scaffolding (Pea, 2004; Lahore, 2005; Puntambekar & Hübscher, 2005), and that a line needs to be drawn between scaffolding with fading and scaffolding without fading. And suggestions about the benefits and challenges of casting our scaffolding net wider. Puntambekar & Kolodner (2005) for example use the term 'distributed scaffolding' and draw our attention to the increased complexity that occurs when scaffolding is distributed and also to the potential for distributed scaffolding to offer learners more scaffolding opportunities. Tabak (2004) also explores complex settings and distributed scaffolding and offers a vision of 'synergistic scaffolding', through which learners can take advantage of different types of support provided by different means in an integrated manner, in order to solve complex problems. To make the task of theory development and design framework specification

more difficult with respect to the use of ubiquitous, tangible and pervasive computing and to support a more distributed approach to scaffolding, the relationship between theories, models, and the development of learning activities and frameworks for their design is complex and the use of terminology is often inconsistent (Conole et al. 2005; Luckin, 2010).

There are important questions that need to be answered if the body of research on scaffolding with technology is to offer a sustainable basis for developing support for learning in technologically complex environments. For example:

- Are all the opinions about scaffolding useful and can they be integrated into a method for probing our scaffolding research legacy or do we need to differentiate between them, argue against some of them and/or come up with something new?
- Are we avoiding tough questions about fading, because new technologies make it hard, or do new technologies enable us to support learners in different ways that mean fading is no longer necessary?
- Should we refine what we consider to be scaffolding and re-visit its roots in Vygotsky's ZPD?
- Can we explore and refine how we can integrate scaffolding to explore the relationships between the resources that a learner brings to their interactions?
- Can we identify the contingencies for scaffolding across multiple technologies, places, people and domains?
- Should we broaden the scope of learner activity in a similar manner to that proposed by those who favour distributed scaffolding, but taking away the classroom boundaries and considering the learner and their interactions more holistically?

In this symposium three speakers: Sadhana Puntambekar, Rosemary Luckin and Joshua Underwood, will consider the manner in which research in scaffolding can help us develop theoretically inspired pedagogical frameworks that will meet the needs of contemporary learners; and three speakers: Danae Stanton Fraser, Chee Kit Looi and Wenli Chen will discuss the possibilities and challenges of supporting learners with pervasive and mobile technologies.

*Sadhana Puntambekar* will discuss the notion of distributed scaffolding and how it applies to supporting students in a classroom. She will discuss how a system of scaffolding can address the complex nature of providing support to multiple students in a classroom. In earlier work she (Puntambekar & Kolodner, 2005), introduced the term distributed scaffolding to refer to the variety of support provided in the complex environment of a classroom. Her research found that multiple forms of support—distributed across available tools, activities, and agents in the classroom and integrated in ways that admit redundancy—enhance the learning and performance of a wide variety of students. In a complex classroom environment, it can be difficult to align all the affordances in such a way that every student can recognize and take advantage of all of them. When support is distributed and integrated and takes multiple forms, it is more likely that students will notice and take advantage of the environment's and activity's affordances. She will discuss how distributed scaffolding relates to the key features of scaffolding, grounded in sociocultural theories of learning. She will revisit the roots of the notion in Vygotsky's theory in the context of supporting students in a classroom.

*Rosemary Luckin and Joshua Underwood* will explore how a redefinition of context from a learning point of view can help us to conceptualize learners and learning in a manner that taps into the intelligence that is distributed amongst the multitude of resources that learners encounter. They will present the Ecology of Resources approach (Luckin, 2010) to stimulate discussion of scaffolding across multiple technologies, people and places. Their presentation will draw upon empirical evidence of learners, teachers and designers using the Ecology of Resources design framework to develop their use of technology to support both science and language learning. The aim being to work towards a way in which we can unpack the manner in which distributed fading might be operationalized.

*Danae Stanton Fraser* will draw upon examples from a variety of research that involves a range of technologies, including the use of sensor technologies for mass participation in environmental monitoring; urban design and pervasive systems; and e-science, to explore the 'loose' notion of scaffolding often used within the field of mobile and ubiquitous learning. She will reflect on a research agenda to examine scaffolding as part of an integral approach to designing mobile and augmented reality environments.

*Chee-Kit Looi and Wenli Chen* will explore the perspective of the scaffolding bridging the gap between abstract or general CSSL design principles and the design and enactment of concrete CSSL practices. In their three-year design research study with Singapore schools, they introduced GroupScribbles (GS) technology coupled with appropriate pedagogical graphic organizers to scaffold effective collaborative learning in the context of second language students' vocabulary learning in Singapore classrooms (Looi, Chen & Ng, 2010; Chen, Looi & Wen, 2011). Every student has a mobile device in which they can share and organize ideas through virtual sticky notes which can be posted post anonymously and moved about in private, small-group and full-classroom display spaces.

The graphic organizers were designed to alleviate the problem by changing the nature of the vocabulary learning task through highlighting the key disciplinary content and strategies for vocabulary

learning. They can scaffold vocabulary learning by “channelling and focusing” (Pea, 2004). In the GS activity, the organizers help to reduce the degrees of freedom for the task by providing constraints that increase the likelihood of the learner’s effective action (focusing on all key components of vocabulary learning such as the meaning, structure, homophones, similar characters, uses in authentic sentences etc). In our interview with one teacher, she expressed her view: “[with the graphic organisers] as time goes on, not only can students’ interest of Chinese characters learning improve, they can internalize these strategies to learn Chinese vocabulary. They can also apply these strategies when they come across a new character or word. After some time, the students may no longer need these tangible scaffolding organizers anymore because they have learned what to do when they learn other new characters or words”. Thus, the teacher’s view is consistent with the expertise reversal effect (Kalyuga, Ayres, Chandler, & Sweller, 2003). When equipped with graphic organizers to help students plan and organize their problem solving, a general technology tool like GS is transformed from a general tool for enabling seamless interactions to a scaffolded software tool integrated with pedagogical design for supporting specific learning, by problematizing important disciplinary content. The distributed nature of the scaffolding is reflected in the support that is distributed across the GS tool, the graphic organizers, the artefacts created, and the different levels of interaction at the individual, intra-group and inter-group levels.

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## Introducing China: Expanding the CSCL Research Community

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**Abstract:** This symposium brings together some of the leading CSCL researchers from China with the purpose of introducing them to the wider CSCL community. China has a strong recent history of CSCL research, but has yet to make real connections to the Western research literature. In part, this is due to the language barrier, but China also holds distinct research traditions, methodological perspectives, and epistemological perspectives about the purpose of scholarly research. We will begin with an overview of CSCL research in China, followed by introductions from six of the leading Chinese researchers, each providing a short summary of their work, including: (1) theoretical perspective, (2) research methods (3) technology infrastructure, and (4) findings and future research interests. Next, we will discuss the future of Chinese CSCL research and its role within the wider community, as well as opportunities for collaboration and exchange.

### Introduction and Proposed Format

Long separated from the West by language and cultural barriers, China is rapidly moving to the center of global discussions in nearly every domain, including agriculture, industry, economics, and most academic disciplines. In recent decades, China has had a strong history of investment in higher education, rapidly constructing universities and investing in research. The number of students enrolled in institutions of higher education increased from 4.5 million in 1999 to almost 30 million in 2010, which makes the Chinese system of higher education the largest in the world (UNESCO 2003). Given the explosive growth of higher education and the smaller demographic cohorts expected in the next ten years, China is on track to have 40% of the eligible cohort attend university in 2020, with new frontiers in continuing education and life-long learning.

In the field of educational research, there is a vibrant community of scholars who are deeply engaged in responding to the growing needs for innovative approaches in the K-12, university, distance and lifelong learning sectors. There is also a long history in China of action-oriented research conducted by K-12 teachers, who work as a tight-knit school faculty, developing rich, multidisciplinary curricula for their students. Such school communities provide a wonderful resource for educational researchers. Overall, there is an excellent climate for CSCL research, and Chinese scholars are expected to produce a record of publications and funded projects.

As CSCL researchers from the West become acquainted with scholars from China, they are recognizing the wealth of ideas and research activity to be found there. Recently, a small conference was convened (Zhao, Wang & Slotta, 2010) where two dozen CSCL researchers from China and North America got together to share their approaches. Out of this event grew a shared understanding of the tremendous potential for both China and West as the traditional barriers that separated those two worlds dissolve. Increasingly, Chinese scholars are researching distance education, ubiquitous computing, collaborative inquiry and many other CSCL topics. This work often includes a unique theoretical lens or innovative methodology that may be atypical of conventional CSCL research. For example, at the recent workshop mentioned above, a comparison study was presented involving 3 different technology-enhanced professional development methods and 400,000 participating schools! Often, Chinese scholars have access to a wealth of multidisciplinary talent and human resources, allowing the development of materials, curriculum and technology systems that rival anything in the West. Still, there is a need for discourse and orientation, as Chinese scholars enter to the global research community. For example, it will be important to welcome Chinese scholars into our research conferences and journals, encouraging and supporting their submissions. This symposium hopes to begin such a discussion, making some personal introductions and encouraging connections and allowing for a discussion of the wider range of issues and opportunities.

### Facilitating Knowledge Building with CSCL: An Empirical Study

*Authors: Kedong Li & Shaoming Chai, South China Normal University*

Information technology (IT) has been applied widely in Chinese schools, but there remains an important question of how to use IT effectively for helping students transform their modes of learning, and achieving a

greater understanding as well as important lifelong technology and inquiry skills. David Jonassen (2005) claims that IT is not only used for supporting teaching, but also used as a tool for knowledge building and knowledge expression. Learners should know how to learn *with* IT, rather learning *from* IT! CSCL is one of the important modes of learning with IT. The purposes of this research thus include: (1) How to facilitate the transformation of students' learning modes in a CSCL environment? (2) How to facilitate knowledge building amongst a community of students using a CSCL approach (3) What are the impacts on student learning of such an approach?

Learning village (LV) is a CSCL platform where students explore topics collaboratively. Learning phases include: (1) Choosing the topics for collaborative learning. Students proposed a number of research questions, such as what are the major issues we are concerned with in our living environment; what are the impacts of the Internet on our lives; or what can we do about the air pollution. (2) Organizing exploring activities within pairing schools. 15 schools in Hong Kong with 13 schools in Guangzhou paired with each other in the first round, and 10 schools in Hong Kong and 10 schools in Foshan paired in the second round for collaborative learning based on LV.

Students were engaged in collaborative learning with support by LV. The learning process includes building house, building road, cleaning road, visiting house, publishing posts, and summarizing and reflecting. The qualitative data has been analyzed using a grounded theory approach. Six categories of data have been analyzed including posting, video clips, students' writings, teachers' narratives, students' online behaviors, and group interaction. An online behaviors analysis framework has been developed for this study with five steps: building the first house, responding questions, deepening questions, collaborative learning, and building knowledge.

**Findings, Outcomes and Future Research**

Based on the critical review of student activities using the Online Behaviors Analysis Framework, three topics were chosen for further analysis. Online interaction structure graphs were constructed, according to the status of students' interaction for the typical learning groups. Figure 1 is one of the results of this study – where the online behaviours and interaction patterns of students can be displayed a progressive chart, as well as in a social network diagram.

案例	房屋	回应方式		回应密度		回应强度		互动方式		互动密度	互动强度	互动深度	
		简单	详细	回应帖子数	有效	无效	高质量帖子数	星型	链型	网状	互动帖的个数/总帖数	有效互动帖数	三级以上有效互动帖数
个案三	2	10	3	37	32	12	3	X	7	X	7/44=15.9%	3	0
	13	16	7	32	37	6	4	5	8	X	11/43=9.3%	11	2
	16	16	6	51	2	4	1	7	9	11	39/60=65%	39	6
	Total	42	16	120	71	22	8	10	24	11	30% (平均)	50	8

Figure 1. The Result of Online Behaviors Analysis.

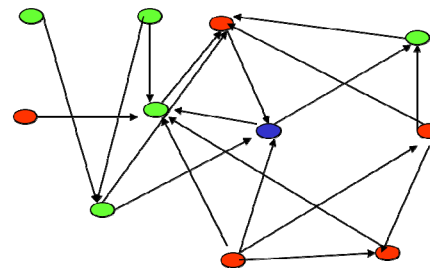


Figure 2. The Social Network within Culture Different Areas.

Based on this research, we have identified three categories of the approaches of knowledge building. The influential factors of LV for students learning have been explored. A general process of social knowledge building has been developed and will be presented and discussed.

**How Position within a Social Network Relate to Knowledge Building in Online Learning Communities**

Author: Lu Wang, Capital Normal University

Online learning communities exist within a wider environment which itself contains a multitude of networks. By obtaining information, producing insight, undertaking analysis and collaboration in the course of knowledge building and by way of an instructed learning process, these networks create all manner of interpersonal associations and learning opportunities. In online learning communities, knowledge is not a static object, but rather something that arises from society, and is implicated in social networks. Learning is not simply a case of receiving independent particles of knowledge, but rather about the active construction of knowledge by social exchange and collaboration between many participants (Cohen & Prusak, 2001; Nonaka & Konno, 1998). According to research carried out on social networks by organizational sociologists, some network positions have been recognized as having a particular influence on individual and group achievements. This is due to the structure of social interactions, which promotes or strengthens personal approaches by way of offering invaluable resources, such as suggestions, information strategies, social support etc. (Brass, 1984; Ibarra, 1993). Moreover many researchers have discovered that within a social network, actors tend to keep their personal strategy in mind; broadly speaking, the strategy of 'being in the right place' (Brass, 1984).

In considering social networks and learning, this research focuses on exploring how network positions are interrelated in online learning communities and the features of network positions with regards to knowledge building. Additionally, where such a relationship is found to exist, this study will explore the patterns thus observed.

Social network analysis, statistical analysis, content analysis and other research methods were used to research online learning communities at Capital Normal University, Beijing. Analysis of the two online courses resulted in the following conclusions: (1) Social networks of the two online courses form typical core-periphery structures; (2) Social networks of the two online courses contain 'structural holes', where some actors position themselves to become potential opinion-leaders within their social networks; (3) Actors, variously positioned within a core-periphery structure, show quite significant differences in terms of knowledge building; (4) Taking 'structural holes' into account, there exist considerable differences in knowledge building between opinion-leaders and non opinion-leaders; (5) Actors in the 'core' and 'structural hole' positions have very different characteristics in terms of knowledge building. These actors in particular play important roles in online learning communities, impacting on the level of the constructed knowledge.

## **Computer Network Supported Collaborative Learning between Urban and Rural Teachers**

*Author: Shaoqing GUO, Northwest Normal University*

Unsurprisingly, the development of ICT for education in the urban and rural areas in China has not been balanced. Rural teachers lack the capabilities of using ICT in teaching, and need more training in terms of ICT abilities. However, there are some problems in the traditional training of rural teachers: short-term, concentrated training cannot really promote teachers' capabilities of using ICT in teaching; in-school training is not effective because of the limited capabilities of core teachers and the lack of support from the schools; systematic guidance and tutoring by experts can only benefit a small number of teachers and cannot be expanded to large scales.

In order to address these practical problems in the training of rural teachers, my colleagues and I explored a strategy and mechanism that can encourage effective learning and professional development of both urban and rural teachers. We examined the following questions in this project: 1) what is the model of creating a learning community for urban and rural teachers and the model of effective learning in such a community? 2) What is the strategy of sustaining the learning community for urban and rural teachers? 3) What is the strategy of transferring the knowledge that teachers acquired in training to the teaching skills they can use in practices? We believe that the result of this study will help us find ways to enhance both rural and urban teachers' information literacy and their capabilities of using ICT in instruction, and thus to change their approaches to instruction.

Using Moodle, we set up an online learning environment for teachers from urban and rural areas. The participants are 50 teachers from 5 schools in Lanzhou City – an urban area – and Linze County – a rural area. They made up 10 collaborative learning groups in this online learning community. This study includes three stages. In the first stage, we trained the teachers and examined their achievement of their learning. In the second stage, we carried out action research on practical teaching subjects. Teachers collaboratively worked on these action research projects and learned from each other as a learning community using the Moodle platform. We collected research data from discussion forms and teachers' blogs on the Moodle platform. In the third stage, we videotaped teachers' teaching practices in classroom. We analyzed these video data to examine effects of our approaches to training.

The result of this study indicates that: 1) An online course platform is an effective way of supporting teachers' systematic learning of professional knowledge in a learning community of urban and rural teachers. 2) A mixed-mode approach should combine short-term training of core topics, self-study, in-school and inter-school training, and collaborative action research supported by online learning system. This model was seen to enhance teachers' capabilities of using information technology, promoting their abilities to learn and interact with peers in an online learning community, and improve their technological pedagogical content knowledge. 3) Collaborative action research activity is an effective way of transferring the knowledge and skills teachers acquired in training to their practical teaching practices. Collaborative action research can help enhance the interaction between the urban and rural teachers, impel the form of learning community of urban and rural teachers, and change the teachers' classroom teaching practices toward a mode of more student discussions and less teachers lecturing. 4) Teachers are starting to implement collaborative approaches to learning in their teaching practices and a learning community that is favour of sustainable professional development is formed.

## **Research on the Organization Model of Ubiquitous Learning Resource — the Structure of Learning Cell and its Runtime Environment**

*Authors: Shengquan Yu, Xianmin Yang & Gang Cheng, Beijing Normal University*

With the development of pervasive computing and Internet technologies, information space will be blended with physical space seamlessly to form a ubiquitous information space combining reality with fantasy. All of them make learning become more and more ubiquitous, which means learning happens anytime, anywhere and on demand. Current researches on ubiquitous learning mainly focus on the construction of conceptual models and supporting environments. However, how to organize learning resources to satisfy the needs of anytime, anywhere, on demand and adaptive learning is an emerging problem. Current learning technologies concern with learning resources sharing in a closed structure, which neglect the sustainable development and evolutionary capability of learning resources, the dynamic and generative connections between learning resources as well as between learners and teachers. Our research focus on solving that problem: to research on the organization model of learning resources and to explore on the organizational framework theory and practical foundations of learning resources within the context of ubiquitous learning supported by pervasive computing technology.

Our research will propose a new description and package mechanism for learning objects, named Learning Cells (LC), which can better support informal learning, and the community construction and sharing of learning resources with the essential features of evolutionary. LC has the basic features of semantic aggregation, self-tracing, evolution, cognitive network connectivity and miniaturization. LC should satisfy the needs of evolutionary development, learning on demand, collaborative editing and dynamic adapting to users and contexts. The core design idea of LC is to introduce a temporal dimension and social cognitive networking into the concept of learning resources to make it evolve over time. Version changes, historical records and user-generated information will all be stored. Meanwhile, a network of knowledge relationships, consisting of knowledge and people, will be formed. The network will be used to promote students' knowledge construction and the sharing of collective wisdom during the process of knowledge evolution. Specific research emphases are as follows:

1. *The logical structure and organizational characteristics of ubiquitous learning resources in a pervasive computing environment.* The general trend of ubiquitous learning resources is generative, adaptive, intelligent and evolutionary. Current learning object technologies tend to focus on the sharing and management of constructed resources, neglecting the life cycle and the learning wisdom accumulated during the application process, which is unable to adapt itself to the future development of ubiquitous learning. In contrast, the LC approach provides resources related to users' learning, as well as a series of activities and tools set within a social cognitive network. LCs are not static learning materials, but a persistent channel for acquiring information and knowledge. Figure 3 displays the basic flow of interactions among learners, LC and other users. With the essential features of openness, generative, evolution, connection, cohesiveness, intelligence and adaptation, LC can realize the evolutionary growth of learning resources and aggregate learning resources and people to form a knowledge relationship network.

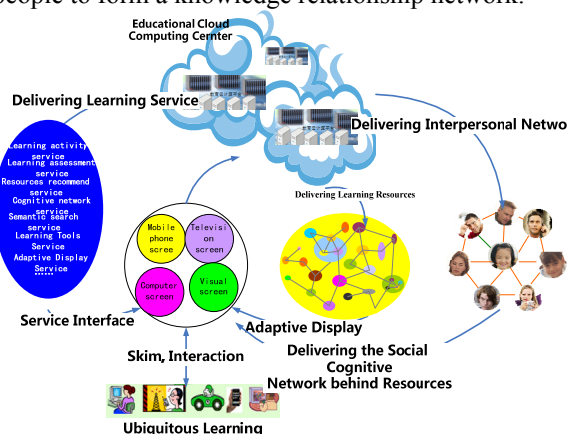


Figure 3. LC: The Ubiquitous Learning Process.

2. *Aggregation Model based on semantics and to control orderly development of resources with semantic gene (knowledge ontology).* LC is a new organizing method for learning resources that applies semantic web and ontology technologies to make learning resource like a living organism that evolve and grow under the control of internal semantic "genes." This research applies ontology and semantic web technologies creatively to construct the aggregation model of ubiquitous learning resource.

3. *Cognitive network computing model for learning resources and expanding sharing range from the materialized resources to social cognitive network.* Related specifications and standards of traditional learning resources are constrained to materialize resources, neglecting the factor of people. Besides materialized resource, there are also human resources connected through materialized resources, which is one key distinction between LC and traditional package model of learning resource. Finally, how to realize the sharing of dynamic social cognitive network through constructing cognitive network model based on uses' interaction and procedural data is one of the urgent problems in need of solution.

This research has combined modeling methods with design oriented methods and empirical research. The technical route is as following: (1) the construction of knowledge ontology model for LC. We have planned to use OWL language recommended by W3 as the basic description language for knowledge ontology. According to general knowledge classification theory, we have designed several basic knowledge types and corresponding attributes. Extended knowledge ontologies can be inherited from basic ontologies.

The operations with knowledge ontology are based on Jena framework published by HP Lab, as well as the ontology searching language SPARQL recommended by W3C. (2) Automatic semantic connection and the construction of social cognitive network. On the one hand, automatic semantic connections among LCs could be built through constructing the similarity or equivalence relationship of field key words; on the other hand, automatic semantic connections could be constructed by analyzing users' learning routes to find out more relationships among LCs. In addition, part of the automatic connections can be realized through inference engines. (3) Realization of the evolutionary feature of LC. The core of our research on ubiquitous learning resources design is how to realize the orderly control of learning resources. Current e-Learning usually takes Web 2.0 as the core technologies in resources evolution, which has brought about a lot of unsatisfactory isolated resources in open environment. LC is expected to realize orderly control on ubiquitous learning resources with semantic technologies.

To date, we have successfully constructed the concept model and information model for LC, designed the package standards, developed the online knowledge ontology co-editing environment and realized the collaborative content editing, version control, and to some extent the knowledge evolution. We have also realized the visualization and sharing of knowledge relationship network with Flex technology and successfully constructed the visual modeling environment for knowledge structure. Next, we will strive for breakthroughs in the orderly evolution of learning resources, including the design and implementation of evolutionary mechanism, the construction of evolutionary model and the development of supporting environments. We have already released the LCPS (Learning Cell Prototype System) at present. You can access it through this URL: <http://lcell.bnu.edu.cn>.

## Semantic Organization of Online Discussions for Active Collaborative Learning

*Author: Yanyan Li, Beijing Normal University*

Online discussion forums provide an open workspace where learners share information, exchange ideas, address problems and discuss specific themes. But a substantial impediment to the use of such environments as effective eLearning facilities lies in the continuously increasing messages but incoherent structure, as well as the loosely connected learners and often random responses. In order to motivate and facilitate active, collaborative learning, this paper describes the design of a forum with semantic link networking on discussion transcripts. Based on domain ontology and text data mining technologies, messages are automatically processed for structural modeling with semantic association, and special interest groups are automatically discovered using topic-centric measures of social context. These measures lay the foundation for new, distinctive functionalities in the semantic forum (i.e. semantic search, relational navigation and recommendation). This paper will address the following research questions:

- How can we organize discussion transcripts in a well-structured and semantic coherent manner?
- How can we connect learners who have similar interests to support their collaborative learning?

Researchers argue that learners' discussion comprises a series of phases, in terms of collaborative knowledge building: information sharing and comparing, concept exploring and discovering, and negotiation of meaning and construction of knowledge. Nevertheless, most research has show that learners' discussion transcripts actually fall primarily into the first phase of information sharing and comparing, so herein we classify the messages types into *Question, Opinion, Suggestion, Recommendation, Request and Citing*. The analysis of discussion transcripts for structural modeling comprises three phases: message topic recognition, message type identification, and semantic association of messages. In the first phase, the messages in a discussion thread are combined into a summary document and then are processed. In the second phase, by analyzing a large amount of messages on the forums, we define the most common patterns and keywords for each type. Afterwards, each initiating-message is parsed to identify the various types of messages in Chinese by following a three-step process: Chinese word segmentation, hint-keywords matching and pattern matching. Regarding the third phase, semantic link network is adopted to organize the messages with semantic associations, where semantic links between messages can be manually defined by forum participants, and automatically be discovered and derived under heuristic rules.

The normal way to analyze the discussion transcripts corpus is to use SNA to count the reply-to relationship between learners, which results in a one-mode network. By adding the topics to which the messages belong, the one-mode network can be transformed into bi-partite network. Additionally, this allows the community to define the knowledge map to express the domain knowledge. By building the semantic mapping from the topics in bi-partite network to concepts in KM, a theme-centered network can be constructed to indicate the persons gathered around one concept. In this way, the theme-centered network denotes the potential interests of the persons, and by adding the reply-to relationship, a special interest group (SIG) can be formed with respect to each concept in the KM. After discovering special interest groups within discussion forums, the next step is to compute criteria for SIG membership, including *participation, mutuality and activity*. Once a learner becomes a member of a special interest group, he will be informed of other learning companions to enhance the in-depth communication and learning, and any new, emerging information related to the SIG will be proactively pushed to him as well.

## Experimental Study and Findings

We used the W3CHINA discussion board (available at <http://bbs.w3china.org/index.asp>) and randomly selected 763 discussion threads in a view of "Semantic Web and ontology", with a total of 4512 messages from the source. Two

postgraduate researchers assessed each discussion thread, manually labeling the messages with the parent concept in the knowledge map and the type of message. We then compared these manual-labeling results with the labels assigned by the automated approach, which revealed that the approach was feasible and effective. Next, by classifying the discussion messages according to theme and identifying their types (using a tool called VINCA) learners' semantic relationship matrix can be obtained and accordingly the networks for SIGs on different themes were discovered. Figure 4 shows the original constructed relationship network on thread "DL" by means of SNA method, in which numerous learners are associated as long as they delivered messages on the theme. Comparatively, figure 5 shows the discovered SIGs on "DL" with additional consideration of message topics. As figure 4 and figure 5 illustrate, the number of learners decrease greatly and the organization structure of the SIGs become more clear-cut and visible.

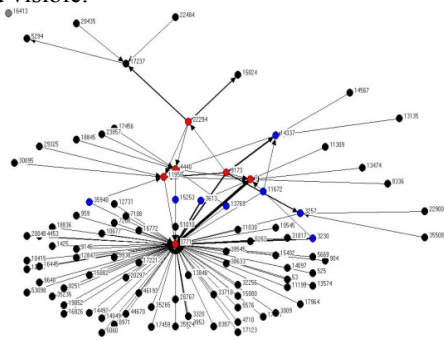


Figure 4. Original Relationship Network on "DL".

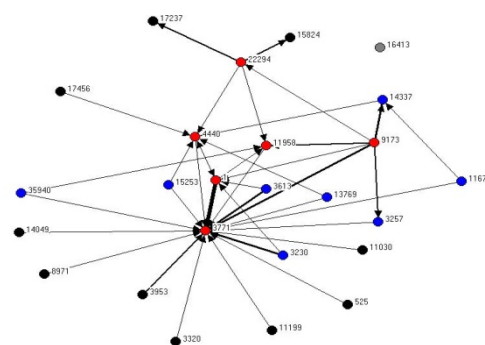


Figure 5. Discovered SIGs on "DL".

Compared with traditional forums, the semantic forum has three outstanding features. First, it deals with the structural incoherence and content isolation within online discussion forums. Second, it enables active learning by providing learners with relational navigation to meet their learning demands. Third, it supports social context based ranking to recommend learning companions or transcripts for collaborative problem-solving. An experimental study will be described that demonstrates the impact of this new technology, showing that the approach is feasible and effective, enabling the dynamic formation of interest groups and demand-driven navigational guidance.

## CSCL-Supported Online Teacher Training: A Case Study

*Authors: Jianhua Zhao, Hui Xu, & Xidiao Chen, South China Normal University*

CSCL offers an ideal setting in which participants' collaboration can be supported by technology. Many studies have addressed this vision, as reviewed by Kienle and Wessner (2005), who analyze the first ten years of the CSCL community. Liu and Huang (2005) have also examined interactions that occur within a CSCL environment.

Our study focuses on how CSCL environment can be used for supporting online teacher training. The research questions include: (1) How to design an effective online course for supporting teacher training; (2) What are the effective methods used for teacher training online? (3) How do teachers respond to our online training? (4) How can we evaluate online teacher training and improve out materials and approaches?

The research methods used in this study include design-based research (DBR), case study, questionnaire, content analysis, and narrative study. 10,000 school teachers from 10 Districts of Guangzhou participated in the study, with 16 tutors from South China Normal University. The online course is titled, "Educational Research for School Teachers." The study employed the Moodle virtual learning environment and included two phases in the training program: online tutor training, and teacher training. The time is from September, 2010 to July, 2012. The design of the online course materials was focused on the notion of "learning by doing," including experiential learning, project-based learning, and community-based approaches. Online teaching methods were defined in terms of the training goals, learning activities, online discussion, experience-sharing, social communication, reflection, interdisciplinary communication, and practice-oriented training. The conclusions of the study will be presented in terms of teacher participation and outcomes of teacher research activities. The presentation will examine the roles of CSCL in teacher training, its function, and teachers' attitudes toward CSCL.

## Design Sharing Mechanism for a Co-Cons Community

*Author: Xiaoqing Gu, East China Normal University*

How can we stimulate people to share their expertise in a virtual community? We focused on this problem in our development of a co-construction system for building learning resources. My presentation will introduce the first phase of our research in which strategies for a sharing mechanism were designed to stimulate participants to share in the system. We began by designing an intervention model from the perspective of social capital, with the intention of creating and sustaining social capital among the participants for the entire process. With data collected from the

first round pilot, we conclude that this design was effective in attracting and maintaining users' interest in contributing to this virtual community, while leaving some designed actions and tools still in need of improvement. These findings will be used to make future modifications of the system.

In order to develop a learning resource where lifelong learners pick up learning materials on the move, we developed a co-construction system (Co-Cons) to engage the diverse expertise of users. Even in an age where there are well established trends toward user-led content, sharing activities that require effort and skill are comparatively less frequent than in a more typical structured online environment that require only simple inputs such as filling in forms or adding comments (Kalmus et al., 2009). This research, is concerned with what drives individuals and how to stimulate their willingness to invest in sharing within this Co-Cons system.

The Co-Cons system works within a life-long learning network (Wang et al., 2009) to enable users who typically have different backgrounds and preferences to collaborate with each other in creating mobile learning resources for practical learning needs (Gu & Li, 2010). The system is designed as an instance of social computing, where the major sharing behavior has been intentionally designed as creating mobile learning resources. To ensure that the resources co-constructed in the system by different users meet a basic quality standard, templates and tools are provided that scaffold and guide the users to design and develop a resource. In the system, a Co-Cons task will be initiated when the practical learning needs expressed by users reach a threshold number. Once the Co-Cons task is established, users interested in the same topic participate in the co-construction of a learning resource. Co-Cons guides the members as they share their expertise in the task area, edit the scripts, and contribute resource material, including social tags and comments. In this process, strangers from across the life-long learning network are supported in a co-construction process with one another. The goals of this research are to design the Co-Cons sharing mechanism in order to stimulate strangers to participate and share in the virtual community, and to build new knowledge about sharing and co-construction within online communities of strangers.

A design-based research (DBR) approach has been used in developing the Co-Cons system, with the sharing mechanism as its key component. This paper explores how the sharing mechanism facilitates participation. The intervention model is used as a framework of data collection and analysis. Findings in this pilot phase will be used to make successive improvement of the mechanism design as well as the Co-Cons system itself. Using an intervention model designed according to social capital theory, we identified factors that mediate willingness to share according to structural, relational and cognitive dimensions. We then designed an intervention model with the intention of increasing these three dimensions of social capital by strategies, functions and tools. This intervention model will work within the Co-Cons system and is expected to foster and increase social capital and therefore foster willingness and participation in the co-construction process.

A group of 17 graduate and undergraduate students from a university in Shanghai participated voluntarily in the three-week pilot from February to March 2010. Four graduate students acted as the volunteer leaders while the other 13 students acted as voluntary contributors in the pilot process. All participants were experienced social computing users. Two co-construction tasks were initiated by the four leaders, and three types of data were collected to see whether the intervention model (i.e., strategies, functions and tools) facilitated this virtual community. Self-report question sheets with 23 questions were provided to the participants at the outset, and participants were asked to make self-reports during the activities. System logs were also collected to capture the level of participation in the pilot process. In addition, a focus group meeting of participants was conducted at the end of the pilot, in an effort to find which functions, tools and strategies were most helpful and in which were in need of improvement.

The findings in this first design iteration have helped us to understand how to foster sharing and co-construction within online communities of strangers. First, we found that the Co-Cons intervention model fostered users to participate and maintain their activity in the community; as well, clearly outlined task description help to draw people together who have mutual interests. Further, the findings of users' interests in the 'Wall' and users' verbal appeal to incorporate more attractive activities confirm that a plan for maintaining interest in a multi-stage style must be in place as this m-Learning project moves forward into subsequent design stages.

## **Design of Museum Exhibits: An Informal Learning Perspective**

*Authors: Jian Zhao, Xianqing Bao, Kangli Li, East China Normal University*

The course of life-long learning is not only constituted by formal schooling, but also includes education in the family, and in society. Even though schools are the main subject of the current educational system, schools only constitute one source of knowledge. Even more knowledge is obtained through various informal learning venues (Banks, et al. 2006). There are many sources of informal learning, including museums, zoos, botanical gardens, and every-day learning (i.e., watching TV, developing individual interests, reading books, shopping). Such informal learning has been addressed by educational technologists and learning scientists, and has become a hot topic for research. Compared to school learning, learning in informal environments can be seen as more random or irregular, making it difficult to control or measure, and there are limited methodologies or theoretical formalisms to address these forms of learning. Because of this, there is far less research in this area than there is on formal school learning, despite the fact that researchers acknowledge the importance of this field.

Museums, which constitute a human-designed environment for learning outside of school, have been seen



by European and North-American researchers as an important path to understanding and researching informal learning. Falk et al. (2005) analyzed a large number of articles and empirical studies to derive a Contextual Model of Learning, which states that the experience of learning in a museum is the result of a combination of individual factors, the physical environment, and social culture. Individual factors include: visitor motivation, expectations, previous knowledge, individual experience, interest, etc. Social culture includes co-visitors and social interactions in the family. It remains to be investigated whether this model is appropriate for Chinese museum settings, and whether it properly reflects Chinese visitors' individual factors. In addition, there is little research about the collaborative and constructivist learning that happens between visitors while visiting a museum. Given these questions, this paper proposes the following research questions:

- What are the factors that impact museum visitors' acquisition of knowledge during a museum visit?
- What is the collaborative learning behaviour of museum visitors?
- Can information technology promote collaborative learning between museum visitors during or after the visit?

Using The Vancouver Pavilion at the 2010 World Expo as a source of data, this paper will (1) evaluate the impact of each exhibit on the visitors, recording and analyzing the behaviour of visitors at each area of the pavilion, and contrasting this with the designer's knowledge frame and intention; and (2) analyze the impacts of different exhibits to explore the relationship between the design of the exhibits and the acquisition of knowledge by visitors. Using a random sample of the visitors to the Vancouver Pavilion, this study employed participant observation, work sheets, and interviews with visitors to collect data about their reactions to the design of the exhibits. It used exhibit design analysis sheets and interviews of the designers to collect data about the design of the exhibits. A second phase of research addressed the use of worksheets to encourage collaborative learning in a museum setting. Using the Shanghai Scientific Museum as a case study, the researchers studied participatory behaviour in some areas of the museum through observation and recording, analyzing the collaborative learning behaviour of the visitors. Next, using a design research methodology, we implemented three cycles of designing participatory learning worksheets and offering these to visitors. Through discourse analysis and the recording of visitor actions, we compare and analyze the impact of worksheets on collaborative learning behaviour.

The data from the first study show that the design of the exhibits certainly impacts the participants' acquisition of knowledge. Moreover, the composition of the visitor groups, as well as their interests and hobbies, can influence how long they stay at the exhibit, which impacts their recall of information about the exhibit. In the second study, we found that worksheets can play an intermediary role in encouraging visitors to ask questions, explain, clarify and engage in other similar behaviour, which increases the interaction within a visitor group. Based on study one and study two, we are designing handheld technology and Web 2.0 technology for use in museum settings to encourage collaborative learning, and to understand its effects.

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## A Principle-based Approach to Knowledge Building: Processes, Challenges, and Implications

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**Abstract:** Collaborative and inquiry-based learning programs vary in the degree of prescription and specification along a continuum from procedure- to principle-based approaches. This symposium will engage researchers and practitioners in a dialogue about these approaches and analyze the enactment of Knowledge Building (Scardamalia & Bereiter, 2006) as a principle-based innovation in two specific contexts: a Canadian elementary school and a teacher network in Hong Kong. Each case will be first analyzed by researchers drawing on rich data collection and, then, reflected upon by practitioners from these two sites (i.e. teachers and principal), followed by questions and comments from symposium participants. Analyzing and discussing these two cases from both researchers' and practitioners' perspectives will help elaborate the possibility, benefits, processes, conditions, and challenges of principle-based innovation in comparison with procedure-based practices and designs. Implications of principle-based innovation to CSCL research and practice will be discussed.

### Focus of the Symposium

Various collaborative, inquiry-based learning programs have been developed to enable collaborative and productive work with knowledge among students with the support of new technological environments (Barron & Darling-Hammond, 2008). These programs vary in the degree of prescription, specification, and structure (Collins, 1996), representing different practices and models for classroom innovation that fall along a continuum from procedure- to principle-based approaches (Zhang, 2010; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). At the procedure-based end innovations are translated into school practice through specification of procedures to be faithfully implemented. Principles are not made explicit but must be inferred from procedures that typically involve carefully sequenced activities and curriculum material and pre-established steps, scripts, and prompts. Collaborative inquiry is accordingly structured through setting up fixed small-groups that deal with assigned sub-topics and tasks following provided procedures, scripts, and templates (see Zhang, Scardamalia, Reeve, & Messina, 2009). At the principle-based end principles are made explicit and presented as pedagogical design parameters with teachers and students engaged as designers and innovators to continually invent and improve principle-based practice through analysis of principles, examples, and results in their contexts. At the midpoint is a principle-based procedure approach in which principles are made explicit and best practices are conveyed through pre-established activities and procedures that translate these principles into effective action. Differences among these approaches on the procedure- to principle-based continuum have triggered ongoing debates and dialogues in the learning sciences (Brown & Campione, 1996; Scardamalia & Bereiter, 2007) that relate to several specific areas of inquiry, including prescriptive, structured versus adaptive, open instructional design (Schwartz, Lin, Brophy, & Bransford, 1999), scripted versus adaptive collaboration (Dillenbourg, 2002; Zhang, in press; Zhang et al., 2009), fidelity and adaptation of curriculum implementation (Brown & Edelson, 2001; Barab & Luehmann, 2003), adoption and transformation of inquiry-based practices in international and cultural contexts (Chan, 2008; Zhang, 2010), and specification of learning design in design-based research (Dede, 2004). The goal of this symposium is to invite deeper conversations about this focal theme through analyzing the enactment of a principle-based innovation—Knowledge Building and Knowledge Forum (Scardamalia & Bereiter, 2006)—in comparison with other learning programs and models in the learning sciences.

### Procedure- vs. Principle-Based Innovation

The three approaches identified above, ranging from procedure- to principle-based, are not meant to describe specific learning programs but rather to suggest the variation of approaches used by learning scientists. Any single program might incorporate aspects of all three approaches, but typically educational approaches fall into the first two (procedure-based, principle-based procedures), reflecting the assumption that educational innovation requires “starter” lessons even “rituals,” so plans, tasks, and activity sequences can be integrated into classroom procedures and become effortless in execution. After teachers have experience they can deal with the

more abstract principles that underlie these procedures and adapt them to their local circumstances (see, for example, scripted collaboration reviewed by Dillenbourg, 2002 and Learning by Design--LBD--Kolodner et al., 2003; Kolodner, 2006). As Kolodner and colleagues explain,

"The rituals give each phase of the LBD cycle some flesh, providing specifics about how to carry them out and clear guidelines for weaving back and forth from phase to phase. Iteration has become a part of the classroom culture that everybody—students and teacher—understand the purpose of and make time for." (Kolodner et al., 2003, p.536).

In several other programs (e.g., Linn, 2006), procedures are conveyed through prompts for explanation, collaboration, reflection, and so forth. Brown and Campione (1994) used activity structures such as jigsaw, crosstalk, and benchmark lessons to establish Fostering Communities of Learners classrooms. They noted an important advantage of their approach: "The repetitive, indeed, ritualistic nature of these activities is an essential aspect of the classroom, for it enables children to make the transition from one participation structure...to another quickly and effortlessly." (p. 236) They also wrote about "lethal mutations" created by the fact that implementers often focus on surface features rather than the underlying principles, thus the procedures themselves became rituals that impede innovativeness (Brown & Campione, 1996). As they elaborate, the procedures lose their effectiveness because they are used too ritualistically and thus are not adapted to local contexts in reflection of the principles. Ironically then, rituals designed to enable innovation might come to stand in its way. Of course, reform-minded teachers need to consider day-to-day classroom procedures and routines. The argument set forth in this symposium is that a principle-based approach may help them to become generative and adaptive in designing, integrating, and enacting classroom processes in light of the ethos of an innovation, and, thereby, be in position to sustain the innovation.

Knowledge Building may well stand alone, far out on the principle-based end of the continuum, as a pedagogical model in use for several decades in nations spanning the Americas, Asia, and Europe, without prescribed procedures to keep it going. Knowledge Building pedagogy and technology (Knowledge Forum) attempt to refashion education in line with how knowledge work proceeds in a knowledge-creating culture (Scardamalia & Bereiter, 2006; Scardamalia, Bransford, Kozma, & Quellmelz, 2010). Knowledge workers build on and advance the knowledge assets of their community (Csikszentmihalyi, 1999; Sternberg, 2003) by generating and identifying promising ideas and improving them through incremental and sustained processes; by formulating deeper problems as solutions are developed; by engaging in idea-centered discourse involving multiple perspectives, constructive criticism, and distributed expertise; by committing themselves to creative goals and careers; by taking risks; and by assuming leadership and responsibility at the highest levels instead of relying on the leader to tell them what to do (Amar, 2002; Bereiter & Scardamalia, 1993; Dunbar, 1997; Florida, 2002; Sawyer, 2007). Correspondingly, knowledge-creating organizations provide supportive, organic, and flexible structures that encourage participatory and distributed control, adaptability, and emergent collaboration (Engeström, 2008; Gloor, 2006; Williams & Yang, 1999). Thus Knowledge Building, as a pedagogical model for enculturating students into authentic knowledge creation practice, has adopted a principle- rather than procedure-based approach to classroom practices, with teachers and their students co-constructing procedures that evolve to remedy limitations and accommodate new possibilities, and supports in place for sharing examples, bringing research to bear on their effectiveness, and in other ways facilitating continual improvement (Zhang et al., 2009, 2011).

As a point of clarification, the Knowledge Building challenge is not to avoid tasks and activities or repeated enactment of effective procedures. Tasks activities, deadlines, and responsibilities, are essential components of any work situation. The challenge is to ensure that idea improvement rather than the completion of a specific task or routine is at the centre of the educational enterprise. If idea improvement is not happening, or is only happening for a limited number of community members, that is a sign that the tasks, activities, and routines need to be improved. Activity structures and procedures must constantly evolve in the service of idea advancement (Scardamalia & Bereiter, 2006, 2007). And for that to happen, teachers and students need to initiate, monitor, and re-structure classroom activities as they proceed (Zhang, 2010).

## Organization of This Symposium

This symposium will bring together researchers and practitioners to have a theoretically informed and empirically grounded dialogue about principle- versus procedure-based approaches to classroom practice and reflect on the enactment of Knowledge Building in two specific contexts: a Canadian elementary school and a teacher network in Hong Kong. The Canadian school, the Laboratory School of Dr. Eric Jackman Institute of Child Study, has been implementing Knowledge Building as a school-wide, principle-based innovation for more than a decade. The Knowledge Building Teacher Network (KBTN), funded by the Education Bureau (Ministry of Education) of Hong Kong since 2006, aimed to scale up Knowledge Building innovation supported with a teacher network, which adopts a principle-based approach to prompt teacher ownership and knowledge creation

for sustained innovation in classrooms. Each case will be first analyzed by researchers drawing on rich data collection and, then, reflected upon by practitioners from these two sites, followed by questions and comments from symposium participants. Analyzing and discussing Knowledge Building initiatives at the above two sites from both researchers and practitioners' perspectives will help elaborate the possibility, benefits, processes, conditions, and challenges of principle-based innovation in comparison with procedure-based practices and designs. Since this symposium will focus on interactive conversations instead of presentations, participants are encouraged to read Zhang et al (2011) beforehand, if possible, and bring their questions and thoughts to the symposium for lively discussions. Questions to be explored and discussed include but are not limited to:

- What are the benefits and challenges of principle-based in comparison to procedure-based innovation?
- What are the critical components of a principle-based innovation (e.g., Knowledge Building) and how do they interact with one another to make new classroom practice possible and transparent to teachers and students?
- Can a principle-based innovation, such as Knowledge Building, be sustained school-wide and increase student engagement and achievement? How will a principle-based approach facilitate teachers and students' knowledge advances? What efforts are needed from the teachers? What conditions might be created in a school to support such efforts?
- Can a principle-based innovation, such as Knowledge Building, be sustained in a larger teacher network? What professional development strategies are effective to support principle-based innovation?
- How can new technology (e.g. collaborative learning environments, assessment and feedback tools) support principle-based innovation?
- What are the larger implications of principle-based innovation to CSSL research and the field of the learning sciences?

## Contributors and Presentations

**Marlene Scardamalia (University of Toronto)** will provide an overview and historical background of principle- versus procedure-based approaches to classroom design and practice and elaborate why and how Knowledge Building pedagogy and technology enacts a principle-based approach. Knowledge Building in classrooms is guided by a set of 12 principles (Scardamalia, 2002), with Knowledge Forum conveying corresponding knowledge operations and interactions and providing affordances for knowledge creation in a community. Knowledge Building practice within a complex, constantly evolving dynamic system is enabled through interrelated systems of support: Knowledge Building principles and Knowledge Forum technology broadly applicable to all classroom initiatives, analytic tools providing indicators of principles in use, and automated tools providing feedback to work as it proceeds. Thus principles and technology combine to provide mutually supportive contexts for high-level knowledge processes. The various components are so intertwined and integral to day-to-day operations that efforts to isolate or prescribe procedures would undercut the dynamic that allows procedures to be continually improved.

An essential component of Knowledge Building is making ideas explicit and public so they serve as conceptual artifacts (Bereiter, 2002) for the community and can be improved by any member. Knowledge Forum provides a shared electronic knowledge space for the community where members contribute and continually advance conceptual artifacts while developing personal expertise and identities. Bringing such community knowledge space to the classroom serves to inform and enhance a focus on collective knowledge advancement, with feedback, interaction tools, and scaffolds (e.g., My Theory, I need to understand) supporting individual contributions and learning as well as collaborative work. These scaffolds are not designed as scripts, but rather as supports for highlighting and turning over to students high-level knowledge processes. To further help teachers and their students use Knowledge Building principles for design and reflection, a set of analytic tools in Knowledge Forum have been designed to provide real-time, on-demand information about students' collective and individual performances, serving as indicators of principles in use as well as providing feedback regarding advances for a broad range of 21<sup>st</sup> century competencies (Scardamalia et al., 2010). The system of interactivity and feedback to knowledge processes that results is very different from that established through activity cycles, step-by-step routines, and various other set procedures built into many educational enterprises. Teachers and students co-construct and reconstruct the flow of things as work proceeds, kicking-off a new inquiry through a new item entered into the database, rallying around an idea and formulating new problems to be addressed, deepen an inquiry by initiating new experiments, rising above previous accounts, and so forth. Visualization and feedback tools help the community identify and focus on the new effort. Overall, the process of knowledge creation is made transparent to teachers and students alike to help them sustain a principle-based approach, with less dependence on pre-established activity sequences to keep the knowledge work moving forward.

**Jianwei Zhang (University at Albany)** will present a study on the implementation of Knowledge Building in the Laboratory School of Dr. Eric Jackman Instituted of Child Study located in downtown Toronto, Canada. Results were analyzed from the perspective of student, teacher, and principal engagement to identify

conditions for Knowledge Building as a school-wide innovation (see Zhang et al., 2011 for details). This study analyzed 39 Knowledge Building initiatives, each focused on a curriculum theme and facilitated by nine teachers over eight years. Analyses of students' Knowledge Forum discourse in the Knowledge Building initiatives showed interactive and complementary contributions to a community knowledge space, conceptual content of growing scope and depth, and collective responsibility for knowledge advancement. More substantial advances for students were related to years of teachers' experience with Knowledge Building. For example, social network analysis of student note reading and note linking interactions indicates that teachers, even in their first year implementing Knowledge Building, created engaged and connected Knowledge Building communities. As the teachers proceeded, they were able to facilitate Knowledge Building initiatives with more productive and sustained contributions, as indicated by the number of notes students created, problems worked on collaboratively, and increases in complementarity of these efforts, which were significantly correlated with the depth of understanding students achieved (Zhang & Sun, 2011).

Analyses of teacher and principal engagement included interviews, observations of weekly teacher meetings, teacher journals, and field notes from classroom observations. A number of supportive conditions were identified for this school-wide, principle-based innovation. At the classroom level, Knowledge Building principles help focus and inform teachers' pedagogical thinking, decision-making, experimentation, and reflection on practice. Contributing factors include teachers' trust in students' capabilities and efforts to continually turn greater agency over to them; ever-deepening understanding of Knowledge Building principles aided by design, experimentation, reflection and research; and teacher willingness to embrace emergence and foster student collective responsibility for co-evolving classroom processes. At the teacher community level, Knowledge Building innovation is sustained by principle-based discourse among the teachers (as well as their students). Knowledge Building principles provide a common language and shared goals—ideals to strive for as they collaboratively deepen the meaning of the principles and co-develop designs, strategies, and resources to support Knowledge Building. At the school level, the Knowledge Building principles help to establish social and cultural norms conducive to creative knowledge work at classroom and teacher-community levels. Collaboration, professional discourse, creativity, autonomy, flexibility, and collective responsibility for high achievements become social values and norms, as well as criteria in hiring new teachers. The principal supports efforts of the individual teachers within their local community as well as dynamic interactions with communities beyond the school.

**Elizabeth Morley and Richard Messina (Dr. Eric Jackman Institute of Child Study of the University of Toronto)** will present teacher and principal perspectives on the enactment of Knowledge Building as a school-wide innovation. Specifically, Richard Messina will reflect on his improvement of classroom designs in light of deepening understanding of the Knowledge Building principles (e.g., epistemic agency, collective responsibility for community knowledge, Knowledge Building discourse). His practice has evolved from fixed small-groups to adaptive, opportunistic collaboration and incorporated increasingly effective designs of Knowledge Building conversations, enabling high-level agency and collective responsibility among students coupled with increase in learning outcomes (Zhang et al., 2009). Elizabeth Morley will reflect on the history of incorporating Knowledge Building and Knowledge Forum into their school and elaborate on her role as the principal, such as: communicating high expectation for teaching excellence and autonomous action; encouraging exploration of new ideas, and conveying trust in teachers; creating social structures and opportunities for teachers to share and collaborate, etc. The teachers and principal meet weekly to share their understanding of the Knowledge Building principles and discuss advances and challenges of classroom designs and practices in light of the principles and evidence collected using the analytic tools of Knowledge Forum.

**Carol Chan, Jan van Aalst, Fung Yuen Han, and Hidy Tse (University of Hong Kong)** will present an ongoing four-year research into a group of teachers in their Knowledge Building Teacher Network in Hong Kong that adopts a principle-based approach. The obstacles, opportunities, refinements and impacts will be discussed. The theme of procedure-based versus principle-based approach is particularly useful for examining classroom innovations in the international context considering culture, technology, and innovation. A delicate tension may exist between lethal mutation when teachers distort the research model to fit with their existing practice (Brown & Campione, 1996) versus adapting and transforming the model in light of the socio-cultural milieu. Principle-based innovation may address such issues of pedagogical transformation in cultural contexts (Chan, 2008; Zhang, 2010). The set of Knowledge Building principles (Scardamalia, 2002) can be used as scaffolds and indicators; while teachers are to retain the deep principles, the classroom activity structures may vary considerably across contexts with scope for the creation of new principles, designs, and practices. Earlier work has shown that teachers in the Hong Kong teacher network tended to focus on activities and resources, but those who grappled with principles had more sophisticated Knowledge Building practice than others focusing on procedures. With two researchers (Chan and van Aalst) and two teachers (Fung and Tse) involved, this presentation will elaborate design efforts towards developing principle-based understanding including how principles are objects of inquiry in teacher discourse and how teachers engage their students in meta-discourse to examine Knowledge Building principles in classrooms. Data analyses will include teachers' changing

understanding of principles intertwined with improvement of practice, and how changes in their epistemology and practice are reflected in student collective knowledge advances in their classrooms over the years. Analyses of how principle-based innovation takes place in the Asian classrooms will also be discussed (Chan, 2008), suggesting the need to continually invent and improve adaptive classroom designs and strategies in light of Knowledge Building principles in response to culture-specific conditions, opportunities, and challenges.

**Janet Kolodner (Georgia Institute of Technology)**, as the discussant, will revisit the variations between a principle- versus procedure-based approach to classroom practice in relation to the implementation of Learning By Design (Kolodner, 2006), a project-based inquiry model in which students deal with authentic design challenges through creating sharable artifacts following clearly laid out activity cycles. She will comment on the enactment of Knowledge Building in the above Canadian and Asian contexts, provide critical analysis, and highlight implications and challenges.

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## Fostering Conceptual Change with Technology: Asian Perspectives

### *Organizers*

Chwee Beng Lee, Nanyang Technological University, chweebeng.lee@nie.edu.sg  
David Jonassen, University of Missouri-Columbia, Jonassen@missouri.edu

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### *Discussant*

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**Abstract:** Conceptual change is one of the most important outcomes of learning. It is an intentional and constructive effort to bring about deep understanding. Researchers in this field have studied various methods and strategies to bring forth conceptual change among learners. We argue that technology can play a critical role in fostering conceptual change. Specifically, it helps learners to externalize and manipulate their internal conceptual models in order to construct or revise their conceptual understanding. When fostering conceptual change with technology, learning is meaningful, effortful, dynamic, and engaging. Through bringing together the work of scholars from various countries, we hope to forward our understanding of fostering conceptual change with technology. In this symposium, the presenters will **provide** general perspectives on the current research fostering conceptual change with technology in Asia-Pacific, **examine** social factors of learning; and **discuss** the possible approaches in various countries.

### **Purpose of Symposium**

Conceptual change is one of the most important outcomes of learning. It is an intentional and constructive effort to bring about deep understanding. Researchers in this field have studied various methods and strategies to bring forth conceptual change among learners. Although conceptual change can be induced through strategies such as using structural alignment as analogical learning (Mason, 2004), collaborative reasoning, (Anderson et. al, 2001; Clark et. al, 2003), knowledge building (Scardamalia & Bereiter, 2006) and many other approaches, we argue that technology can play a critical role in fostering conceptual change. Specifically, it helps learners to externalize and manipulate their internal conceptual models in order to construct or revise their conceptual understanding. When fostering conceptual change with technology, learning is meaningful, effortful, dynamic, and engaging. Through bringing together the work of scholars from various countries, we hope to forward our understanding of fostering conceptual change with technology.

The overarching purpose of this symposium is to present the current state of research on fostering conceptual change with CSCL in Asia-Pacific countries in which technology is fast becoming an integrated part of learning. To accomplish our purpose, the presenters will (a) *provide* general perspectives on the current research fostering conceptual change with technology in Asia-Pacific (b) *examine* the context of learning, learners' characteristics and the role of epistemological beliefs, and (c) *discuss* the different approaches in various countries.

This symposium coincides with our forth-coming edited book *Fostering conceptual change with technology* which is scheduled to be published in early 2012. This will be the first edited book to provide a *comprehensive review* of the research in fostering conceptual change with technology as it captures and documents the related work done by prominent researchers from various Asian-Pacific countries. In addition, this book seeks to provide *varied and multiple perspectives* as it brings together researchers who seek to use technology for conceptual change and conceptual development in learning. Our authors come from 7 countries. Hence, this book will present to the readers how researchers from different Asia-Pacific countries position their research and the current research trends in their countries. In this symposium, we will be informing audience parts of the content of the book.

Our discussion begins with *Seng Chee Tan* giving our audience general perspectives on current research in Asia-Pacific. This provides the audience with a comprehensive overview of current research practices. Next, *Naomi Miyake* will address the issues of context of learning, learners' characteristic and epistemological belief which are critical components of intentional conceptual change process. She will develop these issues on a framework of mechanisms of conceptual change, to draw implications for promoting



technological support. *Jan Van Aalst* and *Chwee Beng Lee* will discuss some different approaches on the use of technology for fostering conceptual change in various countries, focusing on Hong Kong and Singapore.

## Organizers, Speakers, Discussant

This symposium includes leading scholars in related but different approaches in the use of technologies for conceptual change.

### Organizers/Speakers

*Chwee Beng Lee*, Assistant Professor of the Learning Sciences & Technologies academic group at the National Institute of Education, Nanyang Technological University. She is the co-editor of the forth coming book, *Fostering conceptual change with technologies*.

*David Jonassen*, Curator's Professor of Educational Psychology and Learning Technologies at the University of Missouri-Columbia who has is leading figure in learning technologies. He is the co-editor of the forth coming book, *Fostering conceptual change with technologies*.

### Speakers

*Naomi Miyake*, Profesor of Graduate School of Education, University of Tokyo. She is co-director of Consortium for Renovating Education of the Future, to promote learner-centered, collaborative learning to Japanese public schools.

*Jan Van Aalst*, Associate Professor of Education at the University of Hong Kong. His research focuses on knowledge building: pedagogical designs that support it, the analysis of online discourse, and student-directed assessment of knowledge building.

*Seng Chee Tan*, Associate Professor and the Head of the Learning Sciences and Technologies academic group in the National Institute of Education, Nanyang Technological University, Singapore. He has been working on fostering knowledge building among K-12 students and teachers and conducting research related to technology-based pedagogies. He is leading a nationwide study evaluating the impact of the third IT Masterplan in Singapore.

### Discussant

*Peter Reimann*, Professor of Education at the University of Sydney. Peter is the co-founder of the Research Centre for Computer-supported Learning and Cognition (CoCo) Research Centre. His research interests comprise Computer-supported collaborative learning, ICT for formative assessment, and methodological aspects of the learning sciences.

### Session Format

A 90 minutes session is requested to provide ample time for speakers and audience interaction. The session plan follows:

- Chair's opening: 3 minutes
- Presenters' talk: 13 minutes
- Discussant: 15 minutes
- Panel discussion: 20 minutes

### Target Audience

We anticipate that this symposium will attract interest from the following groups of people:

- Researchers and practitioners interested in understanding how to promote scientific conceptual change with technology.
- Researchers and graduate level instructors in educational psychology, learning sciences, cognitive psychology, social psychology, computer science, educational technology and teacher education.
- School educators who are keen to explore the use of technologies for deep learning/conceptual change.

### Speakers' Titles and Summaries

#### **Seng Chee Tan: Current Research in the Use of Technology for Conceptual Change in Asian Countries**

Conceptual change has been extensively studied among educational researchers from a plethora of orientations, theories and disciplines, which include studies on alternative conceptions in particular domains, strategies to overcome these alternative conceptions, theories on concepts and theories on conceptual change. Despite its long history and unresolved controversies, research in conceptual change is continuing to evolve. Using CSCL technologies for conceptual change is one of the emerging themes of study among researchers in the Asian

countries. For example, She and Liao (2009, 2010) developed web-based adaptive programs that are based on multi-dimensional perspective of conceptual change. Building on the adaptive tutorial programs, Yeh and She (2010) showed that inclusion of a collaborative argumentation activity enhances the effectiveness of the program. Li (2006) described the development of MindNet, a computer-supported collaborative concept mapping system, which aims to facilitate conceptual change. Li argued that such co-construction of concept maps help participants to co-develop their evolving understanding of a topic, which leads to both individual learning and group advancement. This coheres well with the knowledge building approach (Scardamalia & Bereiter, 2006) that has also been used as an approach for conceptual change. Working with Canadian students, Chan, Burtis, and Bereiter (1997) found that knowledge building acts as a mediator for conceptual change. van Aalst and Chan continue to pursue this line of research with an emphasis on portfolio assessment. Using design experiments, knowledge building approach was implemented with graduate students in Hong Kong and Canada, 12<sup>th</sup> grade students in Hong Kong (van Aalst and Chan, 2007), and 9<sup>th</sup> grade students in Hong Kong (Lee, Chan & van Aalst, 2006). One of the key interventions was student-directed assessment, where students write a meta-note to reflect on their group processes and advancement in understanding of a topic. It was found that the use of student-directed portfolio assessment, guided by knowledge building principles, correlates significantly with students' conceptual understanding of a topic.

There remain some important works to be done in this field of study. For example, theories of conceptual change have been strongly influenced by Piaget's notion of cognitive dissonance and processes of assimilation and accommodation. The use of CSCL, on the other hand, aligns better with social constructivist and social cultural perspectives of conceptual change (e.g., Greeno & van de Sande, 2007), which are still emerging. To provide stronger arguments for the research findings, researchers need to anchor their research more explicitly on these new perspectives of conceptual change. In addition, the impact of cultural and contextual factors on the use of CSCL for conceptual change in Asian countries could be a fertile ground for research. For example, what are the challenges presented by the strong emphasis on high-stake placement examinations and the competitive culture of individual achievement? In what ways do these factors influence the processes of collaborative learning and conceptual change? How do we overcome these challenges?

### **Naomi Miyake: Fostering Conceptual Change through Collaboration: Its Cognitive Mechanism, Socio-cultural Factors, and the Promises of Technological Support**

Cognitive studies on concept formation and its subsequent change have contributed to refine distinctions between naïve, everyday construction of knowledge and the construction of more scientific concepts. In this presentation I characterize this layered structure of this process as a combination of experience-based, rather individualistic early development of theory-like, folk concepts (Clement, 2008) and more intentionally social and collaborative endeavor which comes later in school learning and scientific community efforts (Miyake, 2008).

Based on this view, I will propose a model for such cognitive mechanisms with explanations of how it is possible (Miyake, 2009; Shirouzu and Miyake, 2009 in Japanese). It has four levels according to what kind of concept is acquired how. Learning of concepts at levels one and two utilizes personal experiences. When a student "forms" a concept by experiencing one instance of some phenomenon, which is in fact possible, this learning is said to have occurred on Level 1. If the same student integrates experiences of repeated encounters of the same, or similar, incident(s), s/he could integrate them into some abstracted concept, or more likely a rule of thumb. When this happens the newly formed concept is a Level 2 concept. When the same individual is introduced to others' and/or more "scientific" concepts, in media or at school, Levels 3 and 4 learning need to start. At Level 4, learners are expected and required to learn scientific, state-of-the-art concepts in adaptive ways, so that they can "use" them in suitable situations, as well as to "maintain" them so that the concept could be changed or expanded, to follow the progress of the science. There is usually a wide gap between understandings of Level 2 and 4, which often causes difficulty in school learning of scientific concepts. The model provides an intermittent level as Level 3, where the learner is expected to engage in repeated, rich collaborative learning experiences to modify the level 2 understanding in various forms, so that the learner can integrate them for abstraction, to reach the Level 4 understanding.

This model calls for collaborative, intentional learning for conceptual change tying different levels, and provides some implications about what we could/should anticipate to happen in classroom practices, with particular emphasis on the aspects of contexts of learning, learners' characteristics and epistemological beliefs of both the teacher and the learner (Miyake, in preparation). Using some concrete examples from the Consortium's current work, I will focus here on a prevalent belief in Japan, that emphasizes one-goal orientation of learning, whose existence is hard to be noticed yet this could have a profound, negative influence of changing the educational practices.

I also plan to review some instructional applications of the above approaches in current CSCL studies in Japan. I will conclude with a call for a stronger IT infrastructure to help promote community building of teachers, learners and citizens who have skill and knowledge to diversify educational situations. This call easily

extends for longer term perspective to support life long learning, to make it possible for every citizen to develop sustainable abilities to keep changing their own concepts whenever necessary.

### **Jan Van Aalst: Knowledge Building for Conceptual Change**

I will review ways in which scholars have challenged or extended the Bereiter and Scardamalia knowledge-building model (Scardamalia, 2002; Scardamalia & Bereiter, 2006). There are four issues to consider. First, I will need to mention briefly need to discuss some important ideas in more depth, including the fit of concepts with the psychological theory of mind on which knowledge building is based, and mention epistemic aspects of conceptual change theories. Second, I will argue that an educational perspective is needed in which students are not just trying to reach a predefined end point, but the question is how far they can advance from where they presently are. Then, I want to expand what we mean by knowledge building by going beyond the focus on idea improvement to knowledge building as a (social) knowledge practice. Here I will draw from important papers on the knowledge-creation metaphor (Hakkarainen, 2009; Paavola, Lipponen, & Hakkarainen, 2004) and my own recent work (van Aalst, 2009).

These ideas are then elaborated by drawing from studies of knowledge building. I will discuss what students learn from knowledge building and some of the factors that influence it. I examine how a specific student approached his online work, examine an example of idea improvement in an inquiry thread, and shed light on some important issues—what happens to misconceptions and how diversity of students' abilities is dealt with. Pedagogical implications for promoting conceptual change through knowledge building are then elaborated.

### **Chwee Beng Lee: Fostering Conceptual Change through Systems Modelling in Problem Solving**

In this proposal, I argue that problem solving as an instruction-induced strategy (see Vosniadou 2007a; 2007b) approach which entails systematic instruction so that learners can understand the complex counter-intuitive scientific theory which has a different explanatory framework as compared to their naïve theories. may foster conceptual change which requires high cognitive engagement (Jonassen, 2008). Specifically, problem solving intervention can: (a) help students to become aware of the inconsistencies between their naïve theories and the scientific ones and (b) create intentional learning and avoid the formation of synthetic models (Lee, 2010). Solving complex and ill-structured problems challenges problem solvers to question their own hypothesis, and externalize the problem, by going through a series of iterative sequences of testing and revising cycles (Lesh & Harel, 2003). The process of problem solving requires problem solvers to actively search for new ways to externalize their problem in order to generate a coherent problem representation. In this sense, restructuring or reorganizing the elements of problems can be regarded as a state of conceptual change. The most important step in problem solving is identifying a problem space that not only enables the restructuring of children's naïve theories but also their modes of learning. When problem solvers build problem representations, they externalize their mental model and making abstract understanding explicit so that they may reflect upon their knowledge and effectively identify their own learning or problem gap. This process is similar to the problem solving processes of scientists as they create models as systems of inquiry and use these models as means which one reasons to the new conceptual representation (Nersessian, 2008).

System dynamic modelling is a highly challenging and engaging activity (Bravo, Joolingen & de Jong, 2009) that requires learners to analyze, synthesize, and evaluate their domain-specific knowledge in order to create a model that supports their conceptual understanding of the system they are working on (Stratford, Krajcik & Soloway, 1998). Numerous studies have documented the successes of using models in problem solving activities in science learning (Stratford, Krajcik, & Soloway, 1998; Lesh, & Harel, 2003). In this proposal, I will discuss how the building of problem representation using systems dynamic models may induce conceptual change and propose for using systems dynamic modelling in collaborative problem solving for fostering conceptual change.

Collaborative problem solving is a rewarding experience and can be an effective way to learn (Gijlers, Saab, Joolingen, De Jong & Van Hout-Wolters, 2009). Several studies have indicated that collaboration can enhance the quality of the learning process and its learning outcomes (e.g. Coleman 1995; Van der Linden *et al.*2000). When students work together to solve complex problems, they need to externalize their conceptual understanding, engage in dialectical argumentation, synthesize divergent ideas and resolve socio-cognitive conflicts. Such high level of commitment and engagement requires necessary scaffolding. Few researchers have developed scaffolds and learning environments that encourage the construction of collaborative representation (see Bravo, Van Joonlingen & De Jong, 2009; Manlove, Lazonder & De Jong, 2006).

However, there remain questions to be answered. Particularly how to effectively capture conceptual change in the process of building collaborative problem representations using systems modelling. Very little research has directly addressed the effects of systems modelling on conceptual change (Jonassen, 2008), let alone the effects of collaborative systems modelling in problem solving for conceptual change.

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## MUPEMURE: Towards a Model of Computer-supported Collaborative Learning with Multiple Representations

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**Abstract:** The aim of this symposium is to advance an integrated framework—Multiple Perspectives on Multiple Representations (MUPEMURE)—for deriving understandings of how CSCL learners generate, share, and navigate multiple representations. We propose to achieve this by exploring synergies between the two bodies of research: learning with multiple external representations (MERs) and CSCL. Research on learning with MERs has the potential of providing useful insights when applied to understanding how CSCL learners generate and work with multiple external representations. Concomitantly, CSCL research has the potential of enhancing the design and explanatory framework of a body of research that has so far largely remained concerned with individual learning. We ground our discussion in four projects that explore different aspects of how CSCL learners can be supported to actively generate, share, and navigate multiple representations and acquire multiple perspectives through specific collaborative designs.

### **CSCL is Learning with Multiple Representations**

When students collaborate in a CSCL environment dedicated to the learning of a complex science topic, they are confronted with multiple forms of external representations (such as texts, diagrams, graphs, equations, etc.) of the topic, and/or they may be asked to collaboratively construct different external representations.

Although there are potential benefits to giving learners the opportunity to interact with multiple external representations (MERs), translating between multiple external representations and mentally integrating them is a difficult and cognitively demanding task (Ainsworth, 2006; Schnotz & Bannert, 2003). In the context of individual learning, research suggested various methods to support learning with MERs: by reducing demanding visual search processes (e.g., Kalyuga, Chandler, & Sweller, 1999) or by directly initiating germane translation processes between MERs (e.g., Bodemer, Plötzner, Feuerlein, & Spada, 2004).

In the context of CSCL, however, research that focuses on the features and demands of MERs is in its infancy. For example, it has been investigated how different representational tools might support collaborative learning (e.g., Suthers & Hundhausen, 2003). Not much research has, however, focused on the complementary question: how computer-based learning with MERs can be encouraged and promoted by collaboration (e.g., Kozma, 2003) and how translation processes between MERs and between learners can be supported during CSCL (Bodemer, 2011).

The main aim of this symposium is to pick up this thread of research on learning with MERs in CSCL and to enrich the so far scarce body of literature with new findings and approaches on MERs and CSCL. We believe—and aim to discuss in this symposium—that learning with multiple perspectives on multiple representations is deeply engrained in CSCL settings, and that CSCL can benefit from taking (research on) multiple representations into account. In doing so, we advance an integrated framework for better understanding of how collaborative CSCL learners share, process and acquire multiple perspectives on multiple external

representations (a Multiple Perspectives on Multiple REpresentations—MUPEMURE model). One way to develop such a framework is to explore potential synergies between the two bodies of research: individual learning with MERs and CSCL.

In research on individual learning with MERs, three main research perspectives have been identified (see Schnotz & Kürschner, 2008). The first two perspectives focus on how learners use different forms of external representations in isolation and/or in interaction with each other to build internal mental models. The third perspective concerns the relationship between MERs and internal (mental) multiple representations in the process of learning. A general theoretical framework—the Design, Function, Tasks or DeFT framework—has been developed by Ainsworth (2006) to examine learning designs that exploit learning with MERs. It also provides a useful lens for understanding how can learners be supported to use MERs in ways that facilitate learning. The DeFT framework examines the *design parameters* (i.e., number/form/sequence of external representations, distribution of information between the representations, support for translation between representations), the *specific functions* of MERs (i.e., to complement or constraint each other with regard to their interpretation, to support the construction of deeper understanding), and the *cognitive tasks* that learners need to engage in when interacting with MERs (i.e., to understand how to coordinate and integrate MERs). In doing so, the DeFT framework goes beyond theories that emphasize and focus on the representational form of information, and proposes a broader set of criteria for designing for learning. At play is an ecology of sensory-motor, perceptual (e.g., attending to, noticing, apprehending, etc.), and cognitive (e.g., organizing, elaborating, explaining, relating, translating, etc.) mechanisms that need to be supported as learners interact with MERs.

However, research on learning with multiple representations has largely remained focused on individual cognition and learning. We argue to extend and apply this research to CSCL settings because CSCL requires learners to construct, share, and work across multiple representations. Furthermore, CSCL with MERs also comprises the very perceptual and cognitive mechanisms at the individual level, but these are dialectically coupled with the additional mechanisms (and burden of) coordination and inter-subjective meaning making of multiple learners bearing multiple perspectives. CSCL with MERs then needs to analyze the back and forth translation between multiple internal and external computer-supported representations of multiple learners (see Figure 1).

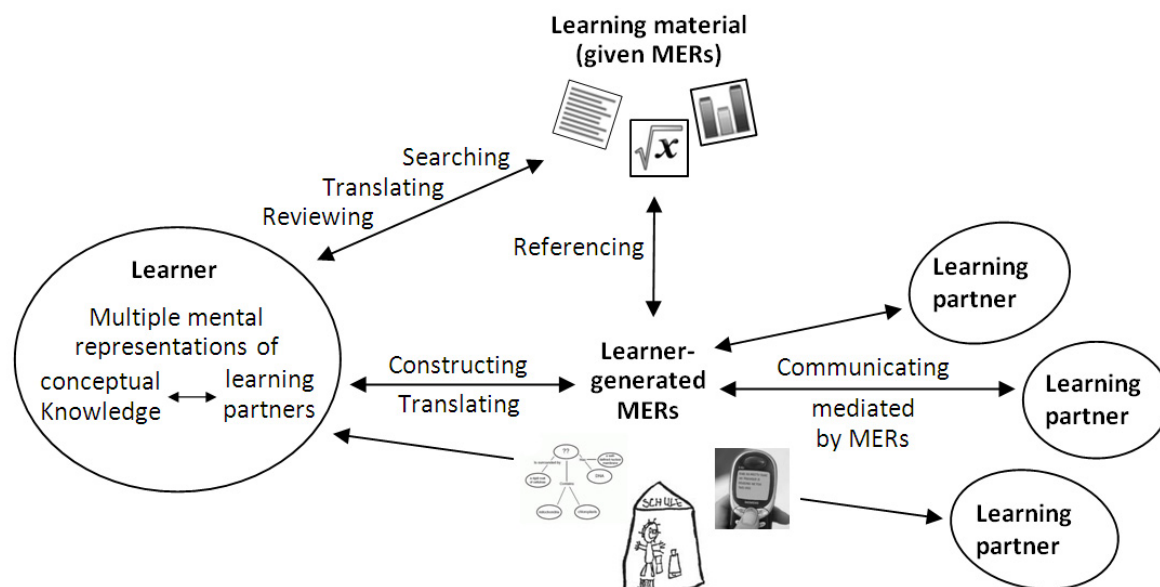


Figure 1. Model of MUPEMURE (Multiple Perspectives on Multiple Representations).

Figure 1 depicts learners who have or are meant to have diverging perspectives on these representations. Resolving the multiple perspectives and converging upon a shared representation has been argued to mediate individual learning (Roschelle, 1992; Weinberger, Stegmann, & Fischer, 2007). MERs may then have different functions for CSCL. For instance, multiple representations may serve to set up CSCL in a way that different learners possess different representations to engage in joint reasoning when resolving inconsistencies and translating between the representations (Slof, Erkens, Kirschner, Jaspers, & Janssen, 2010). MERs take on additional importance in CSCL because these representations are also the medium of communication (Lund, Molinari, Séjourné, & Baker, 2007; Suthers & Hundhausen, 2003). There are, however, also indications that building on multiple representations to share understanding and to convey a complete picture of a phenomenon is difficult for students in comparisons to experts (Kozma, 2003). Against the

background of cognitive load theory, it has therefore been argued that co-constructing MERs should be avoided in favor of worked-out external representations (van Bruggen, Kirschner, & Jochems, 2002). Alternatively, there are also approaches to facilitate sharing and translating between multiple perspectives within CSCL, such as group awareness tools (Bodemer & Dehler, 2011; Buder & Bodemer, 2008) and CSCL scripts (Fischer, Kollar, Mandl, & Haake, 2007; Rummel & Spada, 2005; Weinberger, Stegmann, & Fischer, 2010). In sum, carefully arranging multiple representations to convey multiple perspectives of a phenomenon or as communication media for suggesting learners to engage in specific CSCL activities can be regarded an approach to foster CSCL per se. Simultaneously, coordinating and translating between multiple representations, and ultimately converging upon shared representations can also be regarded a challenge for which particularly computer-supported collaborative learners may need additional support in form of CSCL scripts and group awareness tools.

An important theoretical and empirical opportunity beckons: Research on learning with MERs and the DeFT framework have the potential of providing useful insights when applied to understanding how CSCL learners generate and work with multiple external representations. At the same time, CSCL research has the potential to enhancing the design and explanatory framework of a body of research that has so far largely remained concerned with individual cognition and learning. It is precisely the abovementioned opportunity that this symposium aims to explore.

### **Structure of the Symposium**

We will initiate the symposium with a brief presentation of the proposed MUPEMURE model. Four projects highlighting different aspects within the envisioned MUPEMURE model will then be introduced briefly. Although the four studies involve participants across several age groups and subject domains, what is invariant across the studies is that all four are concerned with how learners individually and collaboratively construct and learn with MERs. What varies across the projects is the manner in which learners can be supported in the process of learning with MERs. More specifically, Project 1 explores the problem of translating between multiple *self*-generated representations, and constitutes a departure point for balancing CSCL support for learners to either fail or succeed in a way that is productive for learning (Kapur, 2009; Kapur & Rummel, 2009). In Project 2, computer-supported collaborative learners have to translate between multiple external representations and are supported by a group awareness tool to do so. The group awareness tool builds on shared visualization of individual task accomplishments of the spatially distributed learners. In Project 3, learners need to explicitly translate between different representations and from individual to collaborative learning phases. This aspect is continued in Project 4, in which students are either made aware of specific aspects of multiple peer- or self-generated drawings of science phenomena or are scripted to first construct an individual drawing and then to systematically compare the drawing with a drawing of a peer, and point out and resolve differences between the drawings.

For each of these projects, we discuss how learners of different age groups generate representations, how these representations facilitate as well as constrain attention, interpretation, and perspectival plurality, how the socio-cognitive processes and mechanisms embodied in the collaborative designs afford opportunities for explanation, elaboration, inter-subjective meaning making, and constructing deeper understanding, and how learners can be supported to do so productively by making learners aware of multiple perspectives of the multiple representations or by scripting learners to engage in activities of comparing and translating between multiple representations. Finally, the discussant of this symposium, Kristine Lund, will relate to and critically comment on the MUPEMURE model and the different vistas opened up by the empirical work shared in this symposium. Finally, we aim to advance the model by involving the audience in a critical discussion aiming towards an adaption of the model.

### **What Type of Support is Needed When Students Generate Multiple Representations in Small Groups?**

#### Katharina Westermann & Nikol Rummel

Research on productive failure has demonstrated that students can learn from unsupported problem-solving in small groups followed by a teacher-led consolidation phase (e.g. Kapur, 2009). More specifically, in the productive failure design, students first collaboratively engage in unsupported problem-solving, generating a diversity of representations as they try different solution approaches. In the subsequent consolidation phase, the generated representations are compared and contrasted in a teacher-led discussion before the teacher finally presents the canonical solution. Thus, at first glance, productive failure looks like an approach without any support during the first phase. However, upon closer inspection in the productive failure studies teachers in fact do provide some motivational or cognitive support during the “unsupported” collaborative problem-solving phase. This leads to the question whether students need at least a minimum of guidance during this phase. Kapur and Rummel (2009) have argued that structuring the learning process from the beginning can either lead to



productive success or to an illusion of performance without learning (unproductive success) whereas delaying structure may result in productive or unproductive failure. In line with this differentiation, we argue in our project that different support types should be distinguished (Rummel & Westermann, 2010) and it remains to be studied which elements of support are needed to make the experiences of failure during the collaborative problem-solving phase productive.

In earlier studies on productive failure (Kapur, 2009), students only received motivational support to persist in generating different representations during the unsupported problem-solving phase. In current studies by Kapur, students are prompted to critically reflect about the representations they generated in order to improve their solution approach from one representation to the next. However, the differences between the former and the latter studies were so far not investigated empirically. To close this empirical gap, we compare two conditions with different support types during the “unsupported” collaborative problem-solving phase: Students in the standard *productive failure* condition (PF) receive motivational support encouraging them to persist in solving a new mathematical problem (e.g. “it is okay to struggle with the problem”; “you are doing a good job”). In the *augmented productive failure* condition (PF+), students additionally receive cognitive prompts, that is, students are supported in their critical evaluation of the representations they generate (e.g. “maybe there are situation where your solution does not work, have a look at this counter-example”). In both conditions, students are expected to try different solution approaches during the problem-solving phase by generating different representations, such as tables, graphs and formulas. Students use tablet PCs to generate, share and discuss representations. Following the productive failure paradigm, the collaborative problem-solving phase is followed by a consolidation phase where the student-generated representations are compared and contrasted in a teacher-led discussion before the teacher finally presents the canonical solution. Also, parallel to Kapur’s studies, in addition to the two productive failure conditions, we implement a *direct instruction condition* (DI) that serves as a control condition. In the direct instruction condition the teacher explains the concept and introduces the canonical solution of the mathematical problem by using different representational formats, before the students solve practice problems in small groups.

Learning outcomes are assessed by an intermediate test after the first phase (collaborative problem-solving or instruction by teacher) and by a posttest after the second phase (consolidation phase or solving of practice problems) to measure the effects of both phases separately. In addition, we implement a two-week delayed posttest. The tests include retention items, conceptual items that test for deeper understanding, and transfer items. Process data recorded from the tablet PCs and audio recordings will enable a detailed analysis of how students generate representations individually and in the group, and how they make connections across representations while being facilitated in different ways. Participants are 170 10<sup>th</sup> graders recruited from two secondary schools in Bochum, Germany.

We hypothesize that the combined support in the PF+ condition best supports students in structuring and developing their ideas and will thus lead to better learning outcomes compared to the PF condition or the DI control condition. Following the discussion of Kapur and Rummel (2009), the PF condition without cognitive support may mark the line between productive and unproductive failure and therefore may or may not outperform the DI condition. The results of the study are presented and discussed at the conference.

Table 1: Conditions of the study.

	<i>Phase 1</i>	<i>Phase 2</i>
<i>PF</i>	Problem-solving in small groups with motivational prompts	Teacher-led compare and contrast, presentation of the canonical solution
<i>PF+</i>	Problem-solving in small groups with motivational and cognitive prompts	Teacher-led compare and contrast, presentation of the canonical solution
<i>DI</i>	Instruction and presentation of the canonical solution	Problem-solving in small groups

## How Can Group Awareness Tools Tacitly Guide Collaborative Learning with Multiple Representations?

### Daniel Bodemer

A main requirement in developing a tool that supports collaborative learning with multiple external representations is the simultaneous consideration of both individual and collaborative processes. In this research project, facilitating group awareness is proposed as a suitable means for reducing unprofitable collaborative effort, and for tacitly guiding learning-relevant interactions while leaving the scope for individual learning processes and their support. Group awareness is an emerging topic in CSSL-research (Bodemer & Dehler, 2011). It covers the knowledge and perception of behavioral, cognitive, and social context information on a

group or its members. A central aim of CSCL-related research on group awareness is the development of tools that tacitly guide learners' behavior, communication, and reflection by the presentation of information on a learning partner or a group. Group awareness tools particularly qualify for being combined with support methods for individual MER-related learning processes because of their representational nature and because they do not restrain individual self-regulated learning processes.

Accordingly, a group awareness tool (collaborative integration tool) was developed and experimentally evaluated that is intended to support collaborative learning with MERs (Bodemer, 2011). It is based on the instructional task *active integration* that has repeatedly been shown to foster meaningful learning processes during individual learning with multiple external representations (e.g., Bodemer et al., 2004; Bodemer & Faust, 2006). The tool enables two spatially distributed learning partners to simultaneously integrate components of differently represented learning material on computer screens. Learners are provided with a shared visualization that contains the current state of integration of both learning partners (see Figure 2).



**Figure 2.** Collaborative integration of multiple external representations during learning statistics. Two learning partners simultaneously drag algebraic components onto the drop areas adjacent to the visualization (learner A's assignments on the left side of each drop area, learner B's assignments on the right side). Four basic cases of knowledge distribution are highlighted.

While interactively integrating different sources of information is intended to support individual elaboration processes by means of external and mental structure mapping, there are other supporting functions that address the collaborative scenario, such as reducing extraneous grounding costs or structuring the learning discourse on the basis of the externalized knowledge distribution (e.g., discussing conflicting knowledge constellations).

The collaborative integration tool was experimentally compared to an integration tool without awareness component (study 1) and to a joint integration condition (study 2). In both studies university students were paired into dyads discussing statistics concepts underlying the one-way analysis of variance. It showed that providing group awareness during collaborative learning with multiple external representations can lead to better individual learning gains by reducing demanding processes and by tacitly guiding learner interactions (Bodemer, 2011). Analyses of the learners' interactions revealed that learners with group awareness support were more involved in meaningful discussions and spent less time for extraneous grounding and modeling processes. Moreover, it showed that learners adapted their discussion behavior to their awareness of knowledge distributions (i.e., talking about perceived conflicting perspectives in a more interactive way).

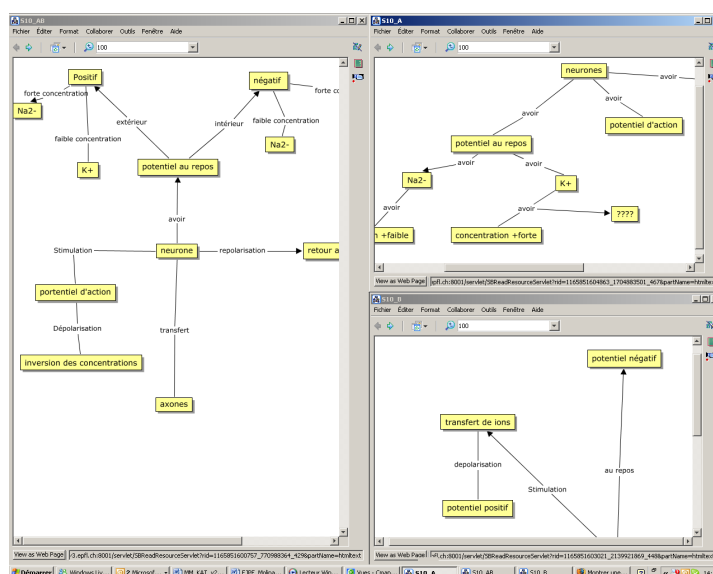
## How Do Co-Learners Build a Collaborative Concept Map Using Visualizations of Their Either Similar or Complementary Prior Knowledge?

Gaëlle Molinari, Mirweis Sangin, Marc-Antoine Nüssli, & Pierre Dillenbourg

In the present contribution, we report an exploratory analysis of how co-learners with either similar or complementary prior knowledge use and articulate their personal knowledge maps in a collaborative concept-mapping task. Concept mapping is a technique that can be used for the visualization of knowledge in both individual and collaborative learning settings. Concept-map building positively contributes to the learning

process and triggers positive attitudes among learners by making them aware of their misunderstandings (e.g., Horton, McConny, Gallo, Woods, & Hamelin, 1993). Other research (e.g., Lund et al., 2007) explored concept mapping in CSSL activities and showed that the collaborative construction of concept maps creates opportunities for knowledge externalization and negotiation of meaning.

In a previous study presented at the ICLS conference 2008, Molinari, Sangin, Nüssli, and Dillenbourg (2008) focused on visual and action transactivity in collaborative concept mapping. In this study, university students collaborated remotely in dyads; they were asked to build a joint concept map to visually represent their shared understanding of a science topic (the neuron physiology). While building the collaborative map, peers were provided with visualizations (in the form of personal concept maps) of both their own- and their partner's prior knowledge. Personal knowledge maps were constructed by learners themselves after the reading of a text (on the neuron) in a first individual learning phase. Two eye-trackers were used to record peers' eye movements during the course of collaboration. The aim was to investigate how co-learners distributed their visual attention across the three concept maps (collaborative map, own- and partner's personal maps). In particular, the question concerned the extent to which peers visually referred to their partner's map while interacting together (visual transactivity). Action transactivity was also analyzed as being the degree to which co-learners manipulated their partner's contributions in the collaborative map. The other objective was to understand how a collaboration script designed to provide co-learners with either similar or complementary prior knowledge (knowledge interdependence script) could affect visual and action transactivity. In the individual learning phase, two conditions were designed. Both peers individually read the same text in the "Similar Knowledge" (SK) condition while each of them read one of two complementary texts in the "Complementary Knowledge" (CK) condition. The main results (Molinari et al., 2008) showed that peers focused twice longer on their own knowledge map in the CK condition than in the SK condition. There were also negative relations between learning performance and respectively the amount of time spent consulting the own map, the number of gaze transitions between the own- and the collaborative maps. No difference occurred in the extent to which co-learners visually referred to their partner's map between both conditions. Finally, there was a trend for the level of action transactivity to be higher in the SK condition than in the CK condition.



**Figure 3.** Collaborative phase (collaborative map on the left side, learner's own knowledge map at the top of the right side, partner's knowledge map at the bottom of the right side).

In the present contribution, we extended these previous results by investigating how co-learners used and coordinated visualizations of their respective prior knowledge (personal concept maps) to build the collaborative map. Here we focused on structural analyses of personal and collaborative maps; in particular, we analyzed the number of personal map elements (concepts and links) that have been selected and directly incorporated in the collaborative map. The number of new concept-map elements created during collaboration was also analyzed. Finally, we examined the relationships between characteristics of personal and collaborative maps, learners' visual behavior on the three concept maps, action transactivity, and learning outcomes. Another focus was on the effect of the knowledge interdependence script with the main hypothesis that co-learners will more likely to use and articulate their respective personal maps to construct the collaborative map when they shared complementary (CK condition) rather than similar prior knowledge (SK condition). On the one hand, results showed that the higher the number of elements in the personal maps, the higher the degree to which

learners manipulated their partner's contributions in the collaborative map (action transactivity). Moreover, the higher the number of elements common to both personal maps, the less learners focused on their own map. The number of gaze transitions between the own- and the collaborative maps was also negatively correlated to the number of new concept-map elements created during collaboration. Finally, there was no relation between learning outcomes and the number of elements in both personal and collaborative maps. On the other hand, results showed that there was no difference between the SK and CK conditions with respect to the number of personal map elements directly incorporated in the collaborative map. All these results will be discussed in detail at the conference.

## How Can Scripts and Awareness Tools Orchestrate Individual and Collaborative Drawing of Elementary Students for Learning Science?

Hannie Gijlers, Alieke van Dijk, & Armin Weinberger

Graphical representations have the potential to enhance elementary school students' science learning experiences by visualizing unseen and complex information and making abstract information more concrete and understandable (Rennie & Jarvis, 1995). However, the mere examination of representations at times leads to shallow processing of the material. By constructing their own representations of scientific phenomena learners are stimulated to identify and link important and relevant pieces of information and thereby engage in self-explanatory and reflective processes (Ainsworth & Loizou, 2003). Drawing has the potential to serve collaborative learning; it facilitates idea sharing and disambiguation of conceptual understanding. Drawings also allow students to easily inspect and build on the ideas represented by their partner and may help students to maintain a common focus (Suthers & Hundhausen, 2003). We argue that the introduction of computer based drawing tools eases the exchange, comparison, revision, and combination of learners' drawings. Support in the form of scripts, or scaffolds (such as awareness support) can easily be implemented or combined with computer based drawing tools.

The aim of this study is to investigate to what extent instructional support in the form of *awareness features* or *scripting* facilitates learning processes and outcomes of elementary school students who collaboratively construct drawings of science phenomena. In this study, awareness support is focused on learners' intermediate products, i.e. the highlighting of specific objects and characteristics (arrows, labels) represented in learners' drawings. The awareness feature provides feedback on the characteristics of learners' drawings in the form of prompts. Furthermore, a collaboration script will be implemented to support students in the process of discussing their individual drawings, mutually criticize and challenge their individual contributions and eventually arrive at a shared representation of the knowledge domain. Scripts have proven to be a powerful instructional approach to foster specific collaborative activities and interaction patterns, such as identifying conceptual differences, asking thought-provoking questions, integrating multiple perspectives, and / or constructing arguments and counter-arguments (Weinberger et al., 2010). We assumed that whereas the awareness support improves *what* learners consider in their collaborative drawings, the script improves *how* learners deal with the content.

To test these hypotheses, we realized a pre-post-test design with three experimental conditions: 1) Collaborative learning with a drawing tool (control condition), 2) Collaborative learning with a drawing tool with awareness feature (awareness condition), and 3) Scripted collaborative learning with a drawing tool (script condition). Ninety-four 6th grade elementary school students, aged 11-12 participated in the study. All students were paired into dyads with a student from their own school. Students used a computer based drawing tool to work on a drawing assignment on the topic of photosynthesis. Dyads were assigned to one of the three conditions described above. To measure the effect of the instructional interventions (awareness support or script), learning outcomes were assessed using an open recall and a cued recall domain knowledge test. Furthermore, intermediate as well as final drawings were scored. The results show that students supported with the awareness feature or the script demonstrated higher levels of knowledge acquisition on a cued recall test,  $\chi^2(2, N = 90) = 19.80, p = .01$ , as well as an open recall test,  $\chi^2(2, N = 92) = 40.03, p = .03$ , than their peers in the control condition. Furthermore, learners with awareness support drew and annotated less concepts, whereas the scripted learners drew and annotated concepts more than learners without script with the later difference being significant,  $\chi^2(2, N = 44) = 66.89, p = .01$ . The results will be discussed against the background of how collaborative drawing can facilitate elementary children's conceptual understanding and how collaborative drawing should be additionally supported to fully develop the benefits it can entail.

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## **CSSL and Innovation: in Classrooms, with Teachers, among School Leaders, in Schools of Education**

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**Abstract:** We expand the notion of CSSL to understand how people can become more innovative. Good learning designs in CSSL can provide opportunities for students to co-construct ideas leveraging on cognitive diversity, to be creative and to experience the discipline of innovation while at the same time learning curricular disciplinary knowledge. The adoption of CSSL in the classroom necessitates teachers to be innovators that understand and know how to harness the affordances of CSSL tools for effective classroom learning. CSSL is also predicated on the necessary socio-cultural conditions in schools created by school leaders to foster an environment for teachers to be willing innovators and to be able to manage risks. By studying and expanding CSSL from the innovation perspective, we may shed light on the most important factors in translating the various research studies of successful CSSL to impactful real world adoption of these technologies in classroom practices.

### **Introduction**

CSSL shifts the focus of education from learning as acquisition of knowledge and facts to learning as building shared meaning, enculturation into social practices and participation in valued activities situated within a community of practice. Various research studies and practices in CSSL offer the promising approaches for restructuring interactions in classrooms to accomplish this shift. However, spreading and scaling CSSL approaches is not easy (Roschelle, Rafanan, Bhanot, Estrella, Penuel, Nussbaum & Claro, 2009). In this symposium, we examine how recasting CSSL from an intervention framework to an innovation framework could better facilitate spreading and sustaining shifts from knowledge acquisition to enculturation perspectives.

Educational research typically takes an intervention perspective, in which the components of a new approach are packaged as a “thing” which we ask schools to implement with “implementation fidelity” to researchers’ image of “transformed teaching and learning.” However, we observe that when teachers enact CSSL designs in the classroom, they are enacting alternative classroom pedagogies, and oftentimes they are challenged to be versatile and to be able to improvise based on the student’s interactions in CSSL. To spread and sustain these pedagogies, teachers must take risks as they begin to question the traditional assumptions of teaching and learning. Indeed, experimenting with CSSL practices provides a catalyst with which they might begin to view students’ learning and their own teaching in very different perspectives, and reflect on their teaching and facilitation. These observations suggest that in the best CSSL implementations, something different than implementing a packaged thing with implementation fidelity to a researchers’ image of transformed teaching and learning is going on.

Alternatively, CSSL research could take an innovation mindset. In an innovation mindset, we view a class and school as an ecological system with the potential force to change. Classroom structure and culture for social interaction are no longer fixed, but can be designed and adapted with careful consideration of multiple dimensions such as cultural beliefs, practices, socio-techno-spatial relations, and interaction with the outside world (Bielaczyc, 2006). From an innovation mindset, new CSSL technological affordances are not a “thing” to be implemented with fidelity, but rather a representational and communication infrastructure that that lowers the threshold for change. School-based leaders do not merely apply a pre-packaged program, but instead must become champions (Carlson, 2006) who lead teams that create new educational value using the infrastructure. The role of researchers is not necessarily “technology transfer” – making things to deliver to the classroom – but can rather serve as contributing innovation guides, who help schools refine the value proposition of their own transformative work, for example, by helping innovation teams better understand how needs, approaches, benefits and alternatives fit together compellingly and cohesively. Indeed, recent educational research suggests that the new resources that make a difference and last in schools are not “simple resources” that are used in school unchanged but rather are “compound resources” that involve substantial configuration, assembling, and elaboration in schools sites (Fishman, Penuel, Hegedus, Moniz, Dalton, Brookstein, Beaton, Tatar, Dickey, & Roschelle, 2009; Looi, So, Toh & Chen, 2010).

Dillenbourg (2009) further substantiates this view by arguing the need for CSCL research on “design for orchestration” in terms of better understanding of what are the supporting and constraining conditions for productive success or failures of CSCL tools and practices. We see the process of “orchestration” as deeply resonant with the role of innovation champions and team – the leaders of the process of innovation in a specific site. What underlies this notion of design for orchestration is the need to “empower teachers”, and this starts from enabling deeper understanding of the fundamental challenges and issues that teachers are facing with CSCL ideas, tools and practices. The effective adoption and enactment of CSCL approaches and tools in a classroom requires the teacher to be an “orchestrator.” Teachers innovate in the classroom as an orchestrator of a multi-constraint management problem, cognizant of the curriculum, assessment, time, energy, space and safety constraints (Dillenbourg & Jerman, 2009).

This symposium brings together researchers and scholars from Singapore, Spain and USA to expand the perspective of CSCL to studying how people orchestrate innovation in education using collaborative tools. As orchestration occurs at multiple levels, we have organized a series of presentations that begin with orchestrating innovation in classrooms, then continue to discuss orchestration when researchers work with teachers, followed by a discussion of innovation at the level of school leaders, and finally considering how a more innovation-oriented CSCL perspective could be applied at the institutions that train teachers and school leaders. Before introducing each of the presentations, we provide an overview of the challenge and opportunity of linking innovation and CSCL. Our discussants Roy Pea and Tak-Wai Chan will consider how this layered view of educational innovation can in turn inform successful conditions and strategies for CSCL expansion throughout classrooms and schools. By focusing on linking innovation with the practice of CSCL and to the need for transformative policies in educational systems, we aim to contribute to a vibrant discussion of the conference theme of CSCL’s impact on practice and policy.

### **Challenge: The Imperative for Innovation in Schools**

Incorporating an innovation perspective into CSCL could be powerful because CSCL researchers who attempt to impact collaborative learning practices in school often face cultural and epistemological challenges to transform classroom practices and cultures. Dominant cultures in classrooms are still teacher-centric and individual performance based, and collaborative learning practices are not naturally cultivated with the mediation of CSCL technologies alone. This issue would be more prevalent and important in the Asian countries than other western countries, since much of Asian school culture is based on individual performance, competitive assessment, and ability-based grouping. Our interaction and conversation with Singapore teachers shows that they tend to be risk-averse and tend to hold deep concerns and doubts about pedagogical approaches promoting greater student agency and social interaction. They are also specifically concerned with whether such pedagogical approaches would work for academically low-achieving students.

Yet, Asian countries are also very concerned with not just standardized academic achievement but also in cultivating the dispositions and abilities of their human resources to be more innovative. For example, Singapore faces the unique challenge of transforming its disciplined culture into a culture of disciplined innovation. Over the past century and especially the last 40 years, Singapore has been a stellar over-achiever among the high-flying Asian economies. In the Global Competitiveness Index 2010-11, Singapore was rated third, following only Switzerland, and Sweden, with USA coming in fourth (World Economic Forum, 2010). The success Singapore has realized in its education system is exemplary of this competitiveness as evident in its performance in TIMSS in 1999, 2003, and 2007 and in PISA 2010. But as Singaporeans have catapulted their island nation to first world status with accomplishments in a variety of fields of endeavour, they are beginning to question whether the strategies and mindsets that were critical for catching up with the first world will continue to serve them as well in their next challenge: taking leadership in a global exponential economy that demands innovation. Doing so requires radical changes throughout that foster a spirit of risk-taking and openness to people and new ideas. An environment must be created that also encourages tolerance of the missteps that naturally occur in value creation. This challenge presents an important opportunity to Singapore: namely to spearhead the methodical application of innovation practices throughout its education system.

Hence, a focus on linking innovation and CSCL is especially relevant to policy considerations in the Asian region which hosts this year’s CSCL, as the link may serve to highlight CSCL not merely as an intervention for boosting academic scores, but also a potential shift in mindset that opens the door to transforming schools as exemplary sites of innovation. Relating to a dominant policy theme of preparing students to be future knowledge workers, the CSCL approach of knowledge building views learners as workers in a knowledge society, sharing intentionality in wanting to move the communal knowledge base progressively forward. Students in knowledge building classrooms engage in a communal process of creating and improving ideas, and providing rise-above views (Scardamalia, 2002). They can be innovators in the classroom by advancing ideas forward as a learning community. In pedagogies enabled by connected classroom technologies such as the GroupScribbles system, the students are involved in a process of brainstorming and generating ideas which can be then collectively built upon in a process of rapid collaborative knowledge improvement. By doing

so, the students both can learn existing subject matter more deeply, become participants in 21<sup>st</sup> century knowledge building practices, as well as developing the dispositions that allow them to experiment with CSCL practices in the classroom. In the learning sciences literature, there is much focus on learning environments for students to prepare them to be a community of knowledge workers. Student learning is still our ultimate goal, but in this symposium, we want to foreground the role of educators who play a prominent role as gatekeepers to unlocking the potential for students to be innovators.

Teaching for the innovation economy must be improvisational because if the classroom is scripted and overly directed by the teacher, students cannot co-construct their own knowledge (Sawyer, 2000). CSCL approaches and tools offer the potential to transform the classroom experiences from IRE patterns (a teacher initiation (I) is followed by a student reply (R), followed by an evaluation of this reply (E) by the teacher) to more participative patterns. Changing such deep-seated traditional patterns of classroom discourse poses a considerable degree of challenge for classroom reform.

### **Opportunity: Engaging with Teachers and School Leaders as Innovators**

To address this challenge, school leaders need to provide conducive conditions for teachers to enact CSCL practices by reducing the risks of failure. They also have to entangle with different stakeholder concerns on the performances of the student, hence they need to innovate too. They have to explore the space of possibilities as well as constraints so that they can provide the conducive environment for teachers to innovate in the classroom. A culture of social practices for collaborative meaning making has to be enculturated, and teachers play critical roles orchestrating such endeavors in this enculturation process.

In the last 20 years, scholars of innovation have discovered that innovation is not based on a few brilliant and creative inventors and entrepreneurs, that it is rarely a solitary individual creation (Sawyer, 2006). The most important creative insights typically emerge from collaborative teams and creative circles (Farrell, 2001; John-Steiner, 2000; Carlson, 2006). Further, innovations come in part from “users” (such as teachers and students) as well as from “developers” (such as research groups) and “suppliers” (such as technology manufacturers). The pressing problems in the world are large in scale and complex in nature. Problems in schools are also multi-faceted in nature. School leaders require innovative mindsets to participate in transforming teaching and learning. They need collaborative approaches to develop innovative solutions to such problems. Sawyer has argued that today’s most innovative companies have successfully tapped on team collaboration throughout their organization in which staff is encouraged to improvise. In the corporate world, disciplines of innovation have been advocated as a process with which anyone can learn to be an innovator (Carlson, 2006). These disciplines and processes of innovation are believed to be of general applicability to anyone interested in value creation or enhancement. Hence it is advocated that such disciplines are also applicable to creating value in education.

### **Presentation 1: Innovation while Scaling Group Scribbles in Singapore**

Chee Kit Looi & Wenli Chen

In Singapore, we use the Group Scribbles (GS) in real classrooms to support rapid collaborative knowledge improvement (RCKI) by harnessing the collective intelligence that typically lies latent in the classroom. GS is a collaborative platform that enables students and teachers to share and organize ideas through virtual sticky notes which can be posted and moved in private, small-group, and full-classroom display spaces. RCKI seeks to harness the collective intelligence inherent in the classroom to learn deeper and faster, envision new possibilities and reveal latent knowledge. Towards the goals of supporting GS-based teaching and learning innovation, we envisaged nine principles for RCKI in the design of lessons, and worked with teachers to co-design lesson plans and apply these principles (Looi, Chen & Ng, 2010).

In ‘traditional’ classroom protocols, teachers usually do most of the talking, and students are supposed to be listening. The teacher–student ratio in Singapore (typically 1:40) favours a centralised management structure which tends to constrain the classroom discourse (Scardamalia, 2002). In the GS class, the students benefited from being able to fully express their ideas because of the opportunity given to every student to post which helps to democratise the class discussion. The anonymity of the postings in GS helps to create and maintain a safe environment in which differences can be exposed and worked with in a non-threatening way, with reduced personal fears of embarrassment or ridicule. This is especially beneficial for those passive learners and shy students. As the students’ learning interactions are constructed in real time through GS interactions, this provides the foundation for knowledge being evolved as a product of interpersonal meaning making. The construction of knowledge becomes much more of a group achievement, resulting from the intricate semantic intertwining of postings and references rather than being attributable to individuals (Stahl, 2009).

Based on a design research approach, we have worked with more than 10 teachers and more than 200 students from 1 primary school and 3 secondary schools over a period of 3 years to co-design lessons in science, math, English, and Chinese language learning. The teachers and students have routine use of GS technology (at



least 1 hour GS lesson per week) in the classrooms. Thus, our design is not just to introduce GS technology into the classroom, but to transform the classroom to adopt the socio-constructivism pedagogy enabled by GS. We have found that “Design for orchestration” (Dillenbourg, 2009) does not come naturally by introducing GS technology to classroom. Teachers play a key role to make the classroom innovation effective. Most teachers are not trained to be orchestrators with CSCL practices. To empower teachers to innovate to become “orchestrators”, we first need to understand the challenges and issues they are facing with CSCL ideas, tools and practices such as:

1. The effective design of RCKI practices by appropriating the GS principles in real classrooms (integrating specific learning objectives, considering existing classroom culture and students’ ability)
2. The effective enactment of RCKI and GS technology in a classroom
3. The assessment of students’ RCKI practices

To nurture innovative CSCL practices in classrooms, we have further found that design principles (RCKI in our study) are very important. It is much more difficult for teacher to understand RCKI principles than learn how to use the GS tool. Adapting from Ertmer’s (1999) framework on barriers to technology integration, we see there are 2 types of barriers in classroom innovation: first-order extrinsic barriers such as lack of technology access, support and time; second-order intrinsic barriers which include teachers’ beliefs which play an important role in influencing teachers’ instructional decisions and classroom practices (Cohen 1990; Calderhead 1996; Ertmer 1999, 2005). The second order intrinsic barrier for innovation is harder to overcome than the first-order barriers. In many Asian countries teachers believe that having a good exam scores to demonstrate good content understanding is the most important goal for their teaching. For some teachers, understanding, designing and enacting RCKI practices is not their “core business”. Aguirre and Speer (2000) argue that beliefs play a central role in a teacher’s selection and prioritization of goals and actions in her teaching. So many teachers consider the goal of RCKI as “add-on” rather than as the primary goal and action. This will make the innovative classroom activities less effective. In our research we found that those teachers who hold more constructivist beliefs and good pedagogical knowledge on CSCL tend to be more innovative and effective in RCKI practices design and practices than those who held more teacher-centred beliefs and have less CSCL pedagogical knowledge.

Thus we see the need to have a new kind of professional development for teachers which does not aim merely to give teachers skills, lessons plans or projects. Rather it aims to develop teachers’ potential as innovators. To develop this potential, researchers can provide appropriate technical, pedagogical and psychological support in the course of the project, in order to accelerate upward growth of the teachers’ innovation in classrooms.

## **Presentation 2: Innovation through Attention to Successful Patterns of Use**

Patti Schank and Luis Prieto

Many CSCL studies focus on teachers’ implementation of innovations; we focus here on tools to help teachers innovate. The need for adaptation of tools to the local classroom context is fundamental, yet the concern of many educational technology researchers remains on demonstrating fidelity of implementation to researchers’ designs (Mills & Ragan, 2000; O’Donnell, 2008). Support for innovation requires avoiding techno-centric approaches and thinking about how integrated conceptualizations of technology, content and pedagogy knowledge (TPCK) would help teachers and researchers to better understand teaching with educational technologies (Mishra & Koehler, 2006). We attend to how teachers can use technologies like GS (deBarger et al, in press; Dimitriadis et al., 2007; Looi et al., 2010) to enable student-centered learning and knowledge building while addressing teachers’ needs for a repertoire of teaching strategies to select from and adapt as they make ongoing, creative adjustments to their practice, especially in reaction to a variety of rich, constructed student responses.

Two research projects in the United States and Spain have been seeking to support teachers’ enactment of highly interactive, contingent teaching that leads to deeper collaborative knowledge building. Both projects have employed GS, pedagogical patterns, and professional development workshops, not only to promote activities that use this kind of teaching, but also to build their own capacity to develop other innovations. Using a largely bottom-up approach, researchers at the University of Valladolid in Spain introduced GS into early primary school classrooms and helped teachers transform their lesson ideas into GS activities, documenting practices such as common design and enactment patterns and improvisational adjustments to instruction. Using a combination of researcher-developed and co-developed materials, researchers at SRI International in the U.S. introduced GS along with interactive activities and pedagogical patterns, documenting implementation challenges and how teachers adjusted instruction within the provided structure.

Among many lessons learned, both projects highlight the need to complement a focus on patterns with attention to micro-level discourse moves for supporting contingent teaching and to the style with which teachers enact them. The projects have progressed toward more atomic, actionable moves as a way to help teachers to

bridge the gap between theory and practice so that they can innovate more productively in the classroom. For example, researchers in Spain observed that teacher lesson designs, despite being high-level and often implicit in nature (i.e. not exhaustively specified on paper), followed a limited set of atomic design patterns when analyzed (Prieto et al., 2010). Teachers' enactments of those designs also followed a further set of atomic pedagogical patterns. The patterns shared a common trait in that they were more easily translatable to concrete actions with the GS tool and in the classroom. Research efforts that tried to modify teachers' practices by exposing them to researcher-made abstractions (e.g. in training sessions, or through web 2.0 platforms) without direct relationship and immediate benefits to their everyday practice generally did not succeed. However, the use of the uncovered atomic patterns elicited from teachers' practice proved much more successful. For example, in a professional development workshop in which patterns elicited from teacher practice were presented, the teachers were better able to use these patterns as a starting point, design new activities with GS that used these patterns, and reflect on how the activities could be enacted in their classrooms and which ones may be more useful from a pedagogical standpoint.

Researchers in the U.S. found that the teachers enacted most of the provided GS activities and patterns, and that the teachers also created several of their own GS activities based on the provided patterns. However, teachers experienced many tensions around classroom management, such as technical issues sidetracking lesson flow, figuring out the "right amount of time" to allow students to answer questions, and keeping students on task during group work. Further, the quality of the student participation, and the contingent teaching observed, were limited. Teachers often asked students to explain their ideas, but the teachers did most of the intellectual work of building on and connecting ideas and rarely actively engaged students in discussion one another's ideas. We concluded that the teachers needed a broader suite of tools to improve the quality of enactment of patterns in classrooms. Technologies designed for collaborative discussion, even when complemented with patterns designed to provide opportunities for students to share their thinking with others, do not necessarily yield rich discussion; a dialogic style research (O'Connor & Michaels, 2007) in which teachers attempt to respond to a student's contribution from the student's perspective and use their response to invite additional student responses is a critical component of teaching that enables student agency and productive collaborations. To support a more dialogic style in such enactment, the project developed a set of classroom norms for participation, discourse moves for discussion, and decision rules for contingent teaching (Penuel et al., 2010). Preliminary indications suggest promising uptake and outcomes of these additional supports.

By providing a set of building blocks and strategies that can be easily called forth, recombined, and recontextualized in the improvisation of practice, teachers are empowered to implement their own innovative activities. This kind of technological and pedagogical knowledge scaffolding is especially useful in the context of classrooms in which teachers have strong content knowledge but their technological knowledge is segregated from its pedagogical applications. Moreover, a language of moves and patterns can be useful for researchers as a way to better understand how teaching and learning change when technological innovations are put into practice.

### **Presentation 3: CSCL and Innovation Among School Leaders**

Charles Patton and Anwar Chan

Educational institutions, especially successful ones, all face the innovator's dilemma (Christensen, 1997): the very formula for their success, at some point, limits their ability to make continued improvements or to respond to changing conditions. Progress becomes uni-dimensional by definition: either you are headed in the right direction or the wrong direction, and the very novelty of innovation is understood (often rightly) as risk. This is a completely natural, indeed predictable, pattern repeated at many levels from the individual to the organizational. But a growing body of research on innovation (Christensen & Overdorf, 2000; Christensen, Horn, & Johnson, 2008; Owston, 2003) suggests that the pattern is not inescapable. There appears instead to be a constellation of factors – from organizational alignment to clear understanding of what innovation is and how it works to a particular collection of individual knowledge, skills, and abilities (KSAs) – whose presence is arguably essential for meeting the challenge of continued innovation.

In particular, research in innovation practices by Drucker (1985) and others has identified the innovation capacity skills that contribute to, catalyze, or inhibit individuals' ability to innovate. These innovation capacity skills form an interconnected and mutually reinforcing web (see Table 1).

Table 1. Six innovation capacity skills.

<b>Skill</b>	<b>Description</b>
Being Empowered	The skill to recognize opportunities, to look at a situation and imagine other possibilities.
Being Connected	The skill to build up social networks (especially with "weak ties").
Being a Quick Study	The skill to acquire necessary background knowledge quickly.

Being Forward Thinking	The skill to organize, to synthesize, to generalize, and to project.
Being Influential	The ability to reason, argue, and present with linguistic, computational, and technical skill.
Being Aware	The skill to connect general knowledge with the “real world.”

Recently, a combined team from the U.S. and Singapore developed and offered four-day workshop for teachers, school leaders, and Ministry of Education officials in Singapore. The workshop was designed to develop innovation capacity skills among 6 school-based innovation teams in attendance. The workshop drew upon innovation workshops designed for corporations which were developed by SRI CEO and Innovator-in-Chief, Curt Carlson based on his book (Carlson, 2006). The workshop was further based upon a project in collaboration with Girl’s Inc. in which SRI developed, tested, and propagated an after-school curriculum for middle-school girls focused on development of these innovation capacity skills through engagement in technology design. As neither of these approaches seemed entirely apropos for school leaders in Singapore, a new approach that incorporated both CSCL and innovation was developed. The objective was to build the educators’ capacity in adopting innovation as a systematic and robust approach to creating new value and solving existing issues in a coherent manner understood by both the practitioner and stakeholder. The participants are exposed to a systematic framework that helps to articulate clearly the value that they wish to create to their stakeholders. They are trained in techniques that enable them to draw valuable ideas and perspectives from the richness of their cognitive diversity and from awareness of the inherent resources and opportunities they have in creating and sustaining innovation in schools.

The central theme linking CSCL and Innovation in this new framework was nurturing “cognitive diversity.” Cognitive diversity is both a CSCL principle – creating shared meaning by bringing together diverse perspectives – and an innovation principle – achieving insightful problem solutions by leveraging the collective intelligence of a small group. In his book, Page (2007) poses and proves a fundamental theorem on collaborative problem solving:

These four conditions – the problem has to be hard, the people have to be smart, the people have to be diverse, and the group size has to be bigger than a handful and chosen from a large population – prove sufficient for [cognitive] diversity to trump ability. They are not the only conditions under which the result holds, but if they’re satisfied, diversity trumps ability.

**The Diversity Trumps Ability Theorem:** *Given these four conditions, a randomly selected collection of problem solvers outperforms a collection of the best problem solvers.*

We found that by applying the skills and techniques taught during this workshop, the participants were able to iterate their ideas over several rounds in order to further refine the value propositions they developed. Examples of the value propositions are: team teaching in schools, creative use of non-classroom space for teaching and learning real-world concepts, enriching the school grounds with ubiquitous computing, and other equally innovative ideas that are very feasible and aligned with their organizational objectives. CSCL tools such as GS and CSCL techniques such as organizing participants in a jigsaw pattern proved highly relevant to unleashing the innovation potential of the workshop participants.

While the programme is still in its seeding stages, we are already receiving positive responses through the schools’ participation and their teachers’ subsequent initiatives within their schools. The workshop validated our view that educators need to engage with innovation at three levels: supporting organizational innovation, engaging in innovative teaching practices, and fostering innovation capacity in their students. They therefore need a framework for understanding, practicing, and supporting innovation that can unify rather than compartmentalize these three perspectives. As next steps, we are exploring how to sustain the support for learning the discipline of innovation beyond a single workshop through a more continuous model of professional development.

## **Presentation 4: Innovation and CSCL for Schools of Education**

Jeremy Roschelle and Charles Patton

As conservators of “what works” it would seem natural that Schools of Education should tend to be far from innovative in the pedagogies they use to train future teachers and school leaders and thus tend to prepare teachers to replicate traditional models rather than pioneering new forms of teaching and learning. Schools of Education are also service organizations with a tightly scoped mission and have limited options for reorganizing time and resources. In a related project, we are looking at how replacing a textbook with an interactive resource as a basis for courses for teacher candidates can open up possibilities for innovation, even under these circumstances.

The Dynabook Project has started from carefully observing the practice of leading teacher educators in two settings, a general math teacher preparation program at San Diego State University and a special education program at San Francisco State University. We found that teacher educators in these two settings spur innovation among teacher candidates by two basic techniques. First, they use videos and other interactive media elements to richly problematize the challenge of helping students learn foundational mathematics concepts, such as ratio. In particular, they use media to engage prospective teachers in examining students at work, exhibiting both misconceptions and various “correct” strategies. Second, they use interactive technologies to engage preservice teachers in broadening their perspective on how to do mathematics, from “one right way” to solve each problem to exploring multiple means of representation, of engagement, and of action and expression. A further principle in the project, arising from mathematics education research, is to help prospective teachers see mathematics as deeply connected (rather than an isolated series of unrelated topics and procedures).

To further foster these dimensions of innovation, we are designing an interactive mathematics resource that incorporates these insights while addressing a foundational mathematics topic that many new teachers struggle to teach well: the concept of proportionality. This resource, called Proportionality “DynaBook,” incorporates several layers of novel features as teacher candidates work across three strands of proportionality: proportionality in number (ratio), proportionality in geometry (similarity), and proportionality in algebra (linear function). One basic feature is that for each mathematics topic, there are three prominently different routes to engagement: exploring video cases of student thinking, doing a richly interactive lesson with embedded virtual manipulatives, and solving challenging mathematical problems. A second layer of features incorporates principles of Universal Design for Learning (Howard, 2004) to support trainee teachers’ deep engagement in mathematical thinking. For example, a “stop and think” feature prompts teacher candidates to reflect more deeply on their activity. Likewise, a “how do I say it?” feature helps teacher candidates think about mathematical communication – an oft-neglected but critically important aspect of mathematics teaching and learning.

In addition, the Dynabook includes “social media” features that aim to engage cognitive diversity as preservice teachers and their instructors do exercises as part of their courses. These features have much in common with the GroupScribbles platform discussed earlier. For example, one social media feature can capture how diverse candidates solve the same challenging mathematics problem while sharing these anonymously. Examining these different solutions (which can use different tools and approaches) can create awareness of the many different strategies for the same mathematics problem. Another social media feature allows candidates to create and share “tours” through the dynabook. Different tours can highlight different possible progressions of learning activities and the class might consider the merits of different tours for different students or teaching situations. A third social media feature allows participants to share how they have highlighted or taken notes on the same Dynabook pages. For example, different highlighting can reveal teachers’ varying perspectives on what students might find challenging on a Dynabook page or notes might suggest possible strategies for supporting students who are struggling with that page.

We are presently using the Dynabook in design research in both university settings as well as with colleagues in Singapore. We are taking a co-design approach, where teacher educators are co-innovators with us in designing ways to use the new resource that fit their existing courses, yet open up new pedagogical possibilities. Early findings suggest that teacher candidates find the resource engaging and readily discover situations that require deepening their mathematical understanding in order to teach effectively. Likewise, we are finding that preservice instructors are finding the Dynabook both challenging, in that it makes video and interactive media more salient than familiar printed resources and also inspiring in their ability to formulate new lesson plans and strategies for the classroom.

## Discussion Guide

Our two discussants, Roy Pea and Tak-Wai Chan, are familiar with the school and education context in USA and Asia, respectively. Questions they will consider in their discussion include:

1. What new insights and possibilities does expanding CSCL to include innovation open up? Are there any important downsides to expanding CSCL to include innovation?
2. Does framing the adoption of CSCL in terms of “disciplines of innovation” reveal useful commonalities at the different levels considered in this symposium, such as the classroom, teacher, school leader, and school of education levels? How do we recognize innovation in these varied contexts?
3. Is linking CSCL and innovation a good strategy for speaking more strongly and cogently to policy and practice audiences both in Asia and throughout the world?

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## Embedding CSCL in Classrooms: Conceptual and Methodological Challenges of Research on New Learning Spaces

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**Abstract:** This symposium brings together a panel of five groups who are leveraging new technologies to embed CSCL within classrooms. The goal of the symposium is to enter into a conversation with the audience about issues relating to methods and analysis of computer-supported collaboration within formal and informal learning contexts, exploring the future of classroom-based learning, and how technologies will give rise to new kinds of inquiry and collaboration. Our discussions will center on video of collaborative learning provided by each group and commentary from the panel. The symposium will be divided equally between short presentations of the panelists and discussion. The discussion will consist of responses from the audience to the videos, as well as panelists commenting on the data, and expanding or reflecting on comments from the audience in reference to their own work.

### Introduction and Proposed Format

New technologies like multi-touch surfaces, location-sensitive devices and physical computing provide opportunities for transforming classrooms into innovative learning spaces. However, we still have much to understand about how such technologies can be used to transform the physical space and promote new forms of learning and instruction. To make effective use of these new tools, we need to understand how to design learning environments and pedagogical approaches that take full advantage of what they have to offer. Thus, we require research concerning how these new technologies influence the individual learner, group collaboration and whole-classroom in the course of complex collaborative inquiry. This symposium brings together a set of international projects that are exploring the integration of new technologies into classrooms. We seek to broaden the conversation about how to design, evaluate and understand the influence of these technologies.

As the primary goal of this symposium is to generate discussion about the study of new forms of collaborative learning in technology enhanced classrooms, panelists will show a short video clip of classroom activities, accompanied by slides that describe the research design and data collected. The audience will be asked to respond to each clip, commenting on initial interpretations of what is occurring, research questions that they find compelling, and methodological or analytic approaches they would like to consider. Members of the panel will also contribute at this stage, adding perspectives from their own work. We anticipate discussion amongst the audience and panel, with topics related to new learning spaces, such as the nature of collective knowledge, the role of the duration of activities, the physical environment, the pedagogical affordances of multi-touch surfaces, and the nature of participatory simulations. In addition, we expect to discuss common methodological challenges and appropriate research approaches with respect to these new learning spaces.

### SynergyNet: Exploring Design and Pedagogy in a Multi-touch Classroom

Iyad Alagha, Elizabeth Burd, Steve Higgins, and Emma Mercier. Durham University, UK.

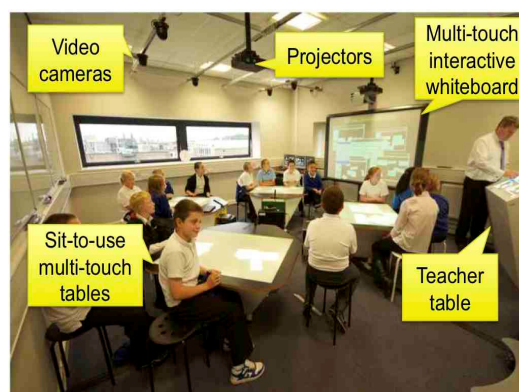
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#### Description

The SynergyNet classroom was designed to integrate multi-touch tables into a typical classroom environment. The data to be presented in this symposium are concerned with how students working on a collaborative mathematics task, collaborated within and between groups to find solutions to problems, and how the orientation of the room influenced the teacher's apparent or actual control and the collaboration between students.

#### Theoretical Perspectives

We approached the design of a multi-touch classrooms recognizing the importance of peer-support and authentic experiences for learning, while also paying attention to the role of the teacher in orchestrating learning opportunities (Dillenbourg & Jermann, 2010). While classrooms are traditionally designed to privilege teacher-led discussions, and teacher-pupil interactions, orchestrating collaborative learning within classrooms requires a



**Figure 1.** The SynergyNet Multi-touch Classroom.

pedagogy that promotes pupil-pupil interaction (Blatchford, Kutnick, Baines, & Glaton, 2003). We focus on understanding how to design and develop classroom activities and pedagogy in a multi-touch integrated space and the role that the teacher and students must take to take advantage of the possible learning opportunities.

### **Technology Environment, Curriculum Materials and Approach**

As can be seen in figure 1, the classroom contains four large student multi-touch tables. The multi-touch tables can detect multiple touches, allowing for joint control of the table and simultaneous manipulation of content (like large iPads). The tables are networked, allowing for movement of content between the tables. There is also a multi-touch orchestration desk, which the teacher can use to send content to the student tables or monitor the content on the tables. The multi-touch interactive whiteboard can be used to project content from the student tables or orchestration desk, to support whole-class conversation about the small group work.

A recent study of this classroom consisted of six groups of 16 ten-year olds from local schools. Two configurations of the classrooms were compared in this study. Three classes were taught with the tables positioned facing center, while three classes were taught in a more typical configuration, with the tables facing towards the large interactive whiteboard. We hypothesized that the second configuration would privilege the teacher's position, while the first configuration would promote between-group conversation. The task that was used for this study was a mathematics 'mystery' in which students receive pieces of information that they need to sort through in order to solve the problem. Mysteries are a pedagogical strategy created for the development and assessment of complex thinking. Each piece of information was written in text on a digital piece of paper. The clues could be moved around the table, reoriented and made bigger or smaller to aid reading or indicate relative importance. For each task there was a single right answer that the groups were trying to reach, and sufficient pieces of information to overload most children's cognitive load, encouraging joint work. The teacher's goals were to foster within and between group collaboration, encouraging groups to solve the problem themselves, then share their strategies with the class. The content on the tables was projected at various points during the task, so that a particularly useful strategy from one group could be shared with the whole class.

### **Methodological or Analytical Challenges**

Exploring the simultaneous between and within group collaboration, and the whole-classroom conversation leads to difficulty defining a unit of analysis and moving between levels of analysis. While traditionally we would focus on either the group or the whole class and teacher led discussion, moving between these results in multiple challenges. These include the need for complex transcription protocols (e.g. a single teacher transcript which is integrated into each group's transcript, which identifies when discussion is between group members, other class members, or aimed at the whole class), and coding in layers to attend to the different interaction levels. Additionally, we are exploring how the teacher's behavior changes under different configurations, how that relates to the students' collaborations and whether and how it has an impact on the students' learning.

## **SAIL Smart Space: Orchestrating Collective Inquiry for Knowledge Communities**

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### **Description**

New forms of knowledge media and data repositories offer opportunities for researchers and curriculum designers to take advantage of the varying contexts (i.e., in the classroom, in field activities) and devices (e.g., smart phones, interactive tabletops, large format displays). This functionality allows for new forms of instruction where students collaborate across contexts, dynamically generate knowledge, build on peers' ideas, and investigate questions as a knowledge community. Our research recognizes the potential of technology enhanced learning environments to support such pedagogical models through physical and semantic coordination. We advance the notion of a "smart classroom," which employs a range of technologies to support our investigations of a spectrum of collaborative inquiry and knowledge construction activities.

### **Theoretical Perspectives**

A research tradition with relevance to the present study is that of the "knowledge community approach" – where students collaborate with peers to develop their own learning goals and approaches for achieving them (e.g. Scardamalia & Bereiter, 1992). The notion of knowledge communities is an ideal complement to the emergence of "Web 2.0" technologies, where knowledge is also seen as an emerging, collaborative product of all users (e.g., Wikipedia; YouTube) rather than a static source provided for consumption. An emphasis on collaborative knowledge creation, coupled with the recognized efficacy of scaffolded inquiry (Slotta & Linn, 2009), raises unique opportunities for curriculum that leverages these information and technology affordances for purposes of

deep conceptual understanding within a knowledge community of peers and teachers (Slotta and Peters, 2009). Rich technology environments can be developed to support such a knowledge community and inquiry approach.

### Technology Environment and Curriculum Materials

Recent advances in CSCL have emphasized technology frameworks where learning content is added and refined by users dynamically during learning activities, with some learning objects gaining content and definition only through patterns of access and use by students. Such content has been referred to as “Emerging Learning Objects,” and often include a versioning system (i.e., to allow all student changes to be tracked) as well as powerful data mining performed by intelligent software agents (e.g. Slotta & Aleahmad, 2009).

We will describe our development of a flexible open source platform called SAIL Smart Space (S3), which in turn builds on the rich framework of SAIL (Scalable Architecture for Interactive Learning – Slotta & Aleahmad, 2009). S3 specifies a framework in which devices and displays are configured, building on 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). Our current S3 smart classroom implementation involves four large projected displays in each corner of a classroom, a fifth, larger, multi-touch display on the front wall, and twenty laptops – all interconnected via high-speed wireless network (Figure 2).

One recent implementation of S3 involved two grade 12 Physics classes, where students were sorted into four groups, with each student in the group assigned four out of sixteen total multiple-choice conceptual physics problems to individually solve and tag (using a set of keywords chosen to represent 12 different physics elements, such as “constant acceleration,” “conservation of momentum,” etc.). Once the first solving and tagging phase

was completed, students remained in their groups where they were shown four of the questions along with the aggregate of the all answers that had been posted (from the wider class) to those problems. They were then asked to form a consensus concerning a “final answer,” a final set of tags, and a rationale for their choices.

To investigate the role of large displays, two conditions were enacted. In the first, students used only laptops (and not the large displays) for all steps in the intervention; in the second condition, all group work was projected from the group laptop onto the group’s corresponding large display. There was a significant difference between these two conditions, in terms of the group’s problem solving and tagging success, with the shared display groups showing higher gains in their correct answers (from 50% to 81.25%) as compared with the group who used only laptops (from 60.38% to 69.23%). One possible explanation is that the large format displays provided the teacher with the ability to see what students were writing in their summary responses, and engage them in meaningful interactions. For example, in one episode, the teacher was watching one group discussing the aggregated answers of the class and saw that *no* students from the individual phase had approached the problem correctly. In other words, the aggregate data was completely incorrect! The teacher was able to intervene, advising students (in this case) not to listen to “the wisdom of the crowd.”

### Methodological or Analytical Challenges

Several challenges arise in this work concerning the “collective knowledge”, artifacts, and complex forms of discourse generated by the various configurations of students and groups. From the problem solving results, it is possible to show that students are gaining a better understanding of the content (i.e., beyond that which they would get from normal class activity). What can the large set of individual student reflections stored over the curriculum reveal about students’ progress, and the role of the wider knowledge community? When the response of the group to the short answer problems is different from that of individual students, what happens to the individuals’ conceptualization? How can such questions be addressed using the data from student reflections? How does the teacher contribute to a knowledge community through his engagement with the students’ aggregated responses and reflections? How can the teacher’s actions be interpreted based on data logs, and their impact on student ideas? We will present video from a recent adaptation of this approach, and discuss our current analytic approach and several directions for future research.

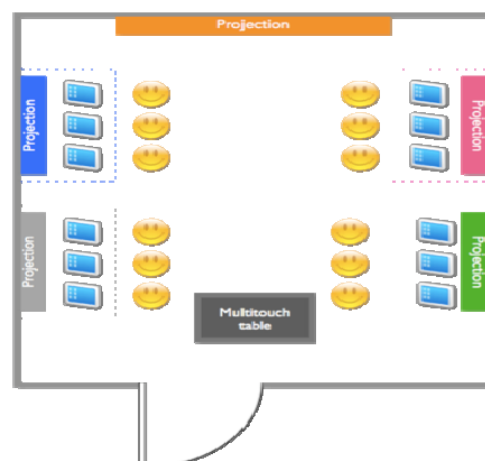


Figure 2. S3 Smart Classroom Setup.



## Identifying Effective Collaboration Scripts for Orchestrating Technology-supported Learning in Innovative Learning Spaces

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### Description

The data presented and discussed were collected in a series of three studies that were conducted in an innovative learning space that included mobile furniture and digital technologies. The studies focused on the question how innovative furniture and CSCL technologies affect learning and how they can be used to better orchestrate and foster student learning. Study 1 investigated in what way students already have access to internal scripts to use innovative furniture and CSCL technologies if confronted with them without having received instructions on how to use them. This was compared to a condition in which students received minimal instruction on the tools' functionalities. Study 2 looked at whether marginal changes in the physical lay-out of an innovative learning space has effects on group performance, individual learning outcomes and emotional well-being. For that sake, students in one condition worked on two tasks while standing at lifted desks, while students in the other condition worked while being seated at a normal desk. Study 3 investigated whether highly structured external scripts are needed in innovative learning spaces to help students produce better group output and reach higher levels of emotional well-being.



**Figure 3.** University Students Rather Sit on the Floor than Re-arrange the Physical Environment.

### Theoretical Perspectives

The project has been guided by a scripting approach (Kollar, Fischer & Hesse, 2006), assuming that powerful and widely shared (internal, i.e. cognitive) classroom scripts (e.g., teacher as expert and evaluator, students as participants with knowledge deficits, in a teacher-led activity ending with the evaluation of the students' performance by the teacher) may impede innovative uses of classroom technology. According to this approach, externally provided scripts may provide students with guidance for effective use of technology and furniture.

We assumed that furniture and computer technology can be designed to support more innovative forms of collaboration between students and teachers, and among students. However, these more innovative classrooms would typically be incongruent with the learners' internal (cognitive) scripts (Schank, 1999) they have acquired in hundreds of hours of school lessons and university seminars. We therefore assume that if left with no instructional support (e.g., by external scripts) students don't use innovative classrooms effectively because of their inappropriate internal scripts and that this may also lead to lower emotional well-being.

### Technology Environment, Curriculum Materials and Approach

262 students participated in three studies on the use of furniture and technology in university seminars in an experimental classroom. The furniture consisted of chairs with wheels, tables that can be easily stored away and lifted to a standing position in order to switch between social levels and postures. The digital technology included laptops with wireless Internet access, an interactive whiteboard, and several large, movable screens.

In the different studies the learners worked on tasks related to presentation techniques and working in groups. For example, they were supposed to learn how to create an effective presentation and to identify the best solution in a decision task in a group. In the former case, we used guidelines and examples for the design of presentations that have been used in regular tutorials at the university. In the latter case, we used standard material for the analysis and training of group decision making tasks (Stasser, & Titus, 1985).

### Methodological or Analytical Challenges

Study 1 showed that if not, or only marginally, instructed, learners had difficulties in appropriately using the new environments for their tasks. Especially with respect to furniture, students seem to have few internal scripts available to guide them in how to create and use supportive environments. Even after being instructed to use the furniture as they need and in how to use the furniture, several groups chose to sit on the floor rather than take time to prepare their environments (Fig. 3). As expected, the acceptance of the innovative furniture and tools was rather low.

Slightly changing the affordances of the learning environment to a realization of a more unfamiliar situation (having to stand during task accomplishment) had negative effects on emotional well-being, but

positive effects on group outputs (study 2). Thus, although learning in an unfamiliar environment may make learners feel uncomfortable, this unfamiliarity may sometimes lead to more effective collaboration.

Results of study 3 showed that with external collaboration scripts learning was to be more effective with respect to knowledge and with respect to collaboration in the new environments than without. Additionally, groups with an external script showed higher emotional well-being than groups who did not receive further support on how to collaborate with each other in this unfamiliar situation. Thus, the results indicate that students need external support to effectively use the advantages that innovative learning spaces offer.

Our current methodological challenges are to find ways to expand the idea of external scripts to whole classrooms, in which such scripts would specify and distribute learning activities and roles over the different social planes of the classroom (plenary, small group, individual; Dillenbourg & Jermann, 2007). Additionally more work needs to be done in the creation of effective classroom scripts to help teachers foster different types of social learning. Another challenge is to find technical solutions for good recordings of what goes on when students use new learning spaces without impeding the acceptance of the learners. Tightly connected to this we explore ways to synchronize data from different sources (logfiles, video data of small group discussions and classroom interaction) to be able to trace computer-supported processes of learning and collaboration through the different social levels.

## Embodied Learning in Embedded Spaces

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### Description

*WallCology* is an agent-based simulation of a small ecosystem (Moher, et al., 2008). The central conceit of *WallCology* is that the walls of a classroom contain a secret, controlled habitat housing a simple ecosystem of endangered flora and small fauna. The students are given collective responsibility for maintaining the viability of the resident species by monitoring those populations and adjusting the heating and lighting of the habitat. A small number of “WallScopes” (computer displays) on the walls around the room afford the visual access to small regions of dynamic behavior in the habitat at their respective locations (Figure 4). Much of the activity revolves around computing and tracking population estimates (typically a dozen times over a month) based on the samples observed through the WallScopes. The class is usually organized in groups of 3-6 students, depending on the number of available WallScopes and class size. The video here shows the work of one group of 10-11 year olds at three sequential points in their collaboration as they identify activity affordances and negotiate their respective roles in the group activity.



Figure 4. Students conduct sample surveys using WallScopes. Sample data are used to compute population estimates for the walls and room.

### Theoretical Perspectives

*WallCology* utilizes the “embedded phenomena” design framework (Moher, 2006), “embedding” learners in the spatial and temporal frames of phenomena while they are positioned as investigators of those phenomena. The pedagogical basis for embedded phenomena derives broadly from theories of situated learning (e.g. Brown, et al., 1989). The embedded phenomena framework situates communities of practice (Wenger, 1998) (in our case, intact self-contained classes) within activity structures (scientific investigations) for the purpose of socially constructing knowledge of science concepts and the processes of science as a technical and human endeavor (Duschl, 2000). The extended duration characteristic of embedded phenomena learning units seeks to afford time for movement from the periphery of practice to more central roles within an apprenticeship context of emerging expertise among peers and teachers. The strategy of “immersing” learners within communities and within the physical and temporal bounds of the phenomena, is designed to raise salience through visual and temporal immediacy. We also seek to leverage potential benefits of embodiment, including the motivational value of a physical activity and positive outcomes associated with engaging in physical actions concurrent with skill development and cognitive offloading (Wilson, 2002) and conceptual learning (Antle, et al., 2009), particular for concepts related to spatial phenomena. By engaging students in authentic science practices, we hope to increase the intrinsic motivation to learn science. Research suggests that students are highly motivated

by engaging in collaborative scientific practice, and that opportunities for both autonomy and challenge are the critical determinants that engagement (Dede, et al, 2005).

### **Technology Environment, Curriculum Materials and Approach**

WallCology requires a set of computers—WallScopes—capable of running Flash, either from the Flash Viewer or a conventional browser. A “Phenomenon Server” housed in our laboratory runs the population simulation, and any registered client can act as a portal into the simulation. (Ideally, the computers should be used exclusively for this application, and run continuously whenever students are in the room.) Stylus or touch-based interfaces support a “tagging” operation for students to apply a small “dab of paint” to the backs of creatures to track their migratory patterns or use sophisticated “tag and recapture” population estimation techniques.

The population tracking and environmental control activities associated with WallCology are conducted within the context of a curriculum unit on plant and animal ecologies. Depending on the grade level and local curriculum, students may investigate life cycles, predator-prey relationships, food chains and webs, the cyclic nature of populations, population estimation methods, and other topics. (We have used WallCology with about 220 students in grades 3-5.) The population estimation activity is interleaved in time within the larger instructional unit, stretching over most of its length. Periodically throughout the unit, the teacher leads full-class discussions focusing on the interpretation of the accumulating data and the decision regarding whether, and if so how, to intervene. Students maintain personal “field guides” (records of their group’s data as well as responses to prompts driven by the larger curriculum unit), and they use large paper sheets taped to the wall to plot population estimates over time.

### **Methodological or Analytical Challenges**

In designing for collaborative activity, it is important that there are enough things for learners to *do*. Observation and reflection are ways of doing, but a design based around one active agent and four silent observers would not have much *prima facie* credibility as a collaborative and/or constructivist environment. WallCology was designed with a “suite” of *participation affordances*, including performing and averaging creature counts, determining area of vegetation growth, estimating population sizes from samples, aggregating data with other groups to develop “whole room” estimates, and others subtasks. We left the organization of teams to the teachers, who most often adopted a strategy of encouraging, but not enforcing, the use of roles within the team.

A time-based *activity record* of how work was distributed within groups could provide important empirical feedback on the adequacy of the activity affordance suite, the effectiveness of collaborative designs in promoting specific participation distribution outcomes, and the relationship between participation and learning. While such records are possible to obtain from video, they require extensive instrumentation (particularly as activity is spread throughout the room), and the viewing and coding of a time series of activity records for an entire class of students is highly labor-intensive. As the whole classroom replaces the desktop as the venue for interaction, the development of new monitoring and location tracking tools has enormous potential for impact on research in embodied learning.

### **Interactive Technologies for Embodied Mathematical Learning: Analysis of Group Cognition in PreK Students Exploring Informal Geometry**

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#### **Description**

The video, observation, and interview data provided by the Interactive Technologies for Embodied Mathematical Learning (ITEML) project was collected in a classroom at the institution’s Child Development Center for Research and Learning, which educates a PreK population. The data illustrates how children, ages 4-5, collaboratively explore mathematical ideas in geometry with virtual manipulatives on a multi-touch, multi-user SMART Table™. This will be presented in more detail in a forthcoming publication (Evans et al, 2011).

#### **Theoretical Perspectives**

Learners activate schemas or frameworks for building knowledge and appropriate new knowledge. This can be accomplished through “actions on cultures,” or through collaborative activity. Co-constructive knowing, as it takes place in knowledge-building communities, has been defined so that “the classroom community works to produce knowledge – a collective product and not merely a summary report of what is in individual minds or a collection of outputs from group work” (Scardamalia & Bereiter, 1994, p. 270). Knowledge-building communities place value on what has collectively been learned and how the learning environments push the boundaries of learning further than ones that focus on individual work. These ideas lead to the following research priorities:

- *Inquiry*: provides an authentic context for exploring mathematical ideas as students identify potential solutions to validate amongst peers and experts (Brown, Collins, & Duguid, 1989);
- *Mediation*: learning is mediated by the use of psychological and instrumental tools. Instructional artifacts include both externally oriented technical tools and internally oriented psychological tools or signs (Ares, Stroup, & Schademan, 2009);
- *Collaboration*: mathematics instruction now advocates the facilitation of the co-construction of knowledge with peers (Enyedy, 2003). Students with similar levels of competence share their ideas to jointly solve a challenging mathematical task that is less likely to be accomplished without collaborative engagement;
- *Discourse*: collaboration is driven by discourse, and knowledge is the product of a process of inquiry. Negotiation as a form of discourse is collaboration, and it is in collaboration that the group becomes defined and thusly the individual finds identity within the group (Stahl, 2006).

Our research attempts to develop a framework for inquiry-based problem-solving activities that promote PreK-2 students' understanding of mathematical concepts in geometry. It proposes a plan to implement and assess the learning outcomes of these activities with a special focus on mathematical discourse and technologies to facilitate this discourse.

### Technology Environment, Curriculum Materials and Approach

Our initial research used physical manipulatives of plastic tangrams to compare to virtual manipulatives using preexisting applications on the multi-touch, multi-user SMART™ Table, utilizing three students and one instructor. While the application allowed for some research opportunities, it contained several features that caused unwanted behaviors hindering research: pieces could be randomly placed within the puzzle causing a mechanism to automatically position, rotate, and lock pieces within the puzzle. This caused students to rely more on the mechanism than on reasoning and collaboration. We designed and implemented a new application with the intent of making it easier to observe the behaviors and interactions of the students with the multi-touch table and each other.



Figure 5. Left: 4-year Olds Solving “Fisherperson” Puzzle. Right: Top Down View of Same Puzzle.

The latest build supports three different scenarios for each puzzle: free, single and divided ownership, which provide the learner with experiences that promote cooperation to aid the development of social skills. In the free ownership mode, learners move any of the pieces in order to complete the puzzle. In divided ownership mode, the pieces are separated into three different colors, one for each learner. In the single ownership mode, one learner can move any of the pieces while the other two learners assist in moving the piece using gestures and dialog. Each of the implemented modes, especially single-ownership, relies on both speech and gesture in order to complete the puzzles. In all modes, we encourage learners to talk together to complete the puzzle.

### Methodological or Analytical Challenges

Our analytic goal is to better understand pivotal moments within small group collaboration among PreK students as well as how particular educational setups (physical/virtual, free/divided/single-ownership, etc.) influenced group knowledge construction. Through coding and identifying patterns in nonverbal and verbal indices of cooperation and focus (including gaze, gesture, manipulation, and speech), we were able to identify moments of discursive cohesion that structure collaborative reasoning. We identify these cohesive points via “coreferences” after McNeill (2009). In its most basic sense, a coreference can be understood as the repeated expression of a single referent, either object, person, or meta-structure, which crosses over verbal and nonverbal deixis, referring to the phenomenon that the denotational meaning of utterances and words is contextually based. Although the field of coreferential and deictic analysis has focused on spoken deixis, we find that especially in the development of mathematical and picture-making skills, observing nonverbal communication is key to understanding how shared cognition facilitates knowledge construction. We have developed a method of multimodal coding, through similar work with data from second graders but with different modalities, to allow us to track nonverbal as well as verbal events over time. The result of our continuing work is an expansive rubric for classifying how action, gesture, and speech relate to and build upon one another during the problem-solving process. We have found that many utterances contain implicit references to geometric principles (e.g., fitting larger pieces in first, properties of the pieces) as well as implicit references to principles governing cooperative problem solving (e.g., turn-taking.). We are interested in how children manifest their understanding of these rules and principles in speech, gesture, and action. Additionally, we investigate how individual coreferences (i.e. with a single referent) constitute larger units of collaboration; that is, how the children form coalitions focusing on a single task, such as, fitting in a single piece, with the greater aim of solving the puzzle.

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## Strengthening the Conceptual Foundations of Knowledge Building Theory and Pedagogy

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**Abstract:** The term “knowledge building,” introduced in the late 1980s, has gradually acquired a distinctive meaning within the family of constructivist approaches in education. It refers to the creation of knowledge as a public good. It represents a positive answer to questions raised in a 1994 paper: “Can a school class, as a collective, have the goal of understanding gravity or electricity? Can it sustain progress toward this goal even though individual members of the class may flag in their efforts or go off on tangents? Can one speak of the class--again, considered as a community, not as a mere collection of individuals--achieving an understanding that is not merely a tabulation of what the individual students understand?” New concepts such as Hakkarainen’s “epistemic mediation,” Stahl’s “group cognition,” Scardamalia and Bereiter’s “improvable ideas” and their distinction between “belief mode” and “design mode” offer insight into how community advances in understanding are achievable.

### Focus of the Symposium

A paper titled “Computer Support for Knowledge-Building Communities” (Scardamalia & Bereiter, 1994) is frequently cited as the definitive representation of knowledge building theory, pedagogy, and technology. However, all of these elements have undergone considerable subsequent development, not only by the original authors and their collaborators but also by others who, while recognizing the early work as a starting point, have proceeded either to infuse new ideas into the original conception or to embed the basic ideas of knowledge building in different theoretical frameworks. The key concept that continues to distinguish knowledge building from other constructivist approaches in education is that of creating knowledge as a public good, as distinct from its construction as mental content or as situated practice. Outside of education, the concept of *knowledge creation* has taken shape referring to the same process (Nonaka & Takeuchi, 1995). In fact, “knowledge building” and “knowledge creation” may be treated as equivalent terms (Paavola & Hakkarainen, 2005). In an educational context, however, it becomes important to establish in what sense students may be thought to create new knowledge (Bereiter & Scardamalia, 2010). More generally, the question “How is it possible?” looms much larger in education than it does in business and research contexts where knowledge creation is pursued. This symposium brings together thinkers who have been working at basic theoretical levels to establish sound and fruitful conceptions of knowledge building/knowledge creation. Among the ideas featured in this symposium are “epistemic mediation,” “group cognition,” “improvable ideas,” and a distinction between “belief mode” and “design mode.” Because of the diversity of ideas represented, this symposium is designed as a highly interactive one between the contributors and the audience, with the chair person moderating the discussion.

### Contributors and Presentations

#### The Role of Epistemic Mediation in Knowledge Building (Hakkarainen, Ritella, & Seitamaa-Hakkarainen)

The evolutionary history of human cognition appears to involve cultural invention of epistemic technologies, such as writing, that radically collectivize cognitive processes traditionally thought of as taking place within the human mind—resulting in what we here discuss as *epistemic mediation*. By *epistemic mediation*, we refer to a process of deliberately re-mediating personal or collective inquiry by creating shareable epistemic artifacts, such

as texts, graphs, and models. It involves efforts of crystallizing, integrating, and synthesizing one's view at the edge of knowledge and understanding and using the resulting knowledge artifacts as a stepping stone for reaching a higher-level understanding at subsequent cycles of inquiry. The advancement of knowledge-creating inquiry appears to depend on a sustained struggle to crystallize evolving understanding in a growing network of epistemic artifacts. These artifacts, in turn, provide implicit or explicit hints and guidelines regarding promising directions of advancement and ways of going beyond the existing epistemic horizon. From an evolutionary perspective the present tremendous expansion of the Information and Communication Technologies (ICTs) is a continuation of the same process of epistemic mediation that took place at the advent of modern civilization and changed the architecture of human cognition as radically as earlier leaps in biological evolution (Donald, 2001). Collaborative technologies empower even elementary-school children in transforming their intangible ideas to digital and, thereby, also materially embodied artifacts with which they can be interact across long periods of time. In order to capitalize on epistemic mediation it appears, however, essential to cultivate shared knowledge practices that channel the participants' efforts into systematic pursuit of knowledge advancement. Knowledge building and other forms of serious inquiry cannot rely on mere oral interaction but must capitalize on epistemic mediation involved in systematic production of epistemic artifacts textual or graphic in nature.

The principal vehicle of epistemic mediation is writing that allows externalization, objectification, and materialization of the processes of thinking and reasoning for shareable epistemic artifacts in interaction with which subsequent inquiry takes place. As Brockmeyer and Olson (2009) argued, writing is not just recording of thought but constitutes its own system that has significant social, intellectual, and cultural consequences. This system relies on material-symbolic practices that enable creation of new kinds of epistemic objects, such as questions and theories, with which we can be in interaction. In order to elicit pursuit of novelty, knowledge-building inquiry has to capitalize on extended cognitive circuits that break boundaries between minds, bodies, artifacts and environments (Clark, 2008). In order to cultivate capacities of pursuing challenging inquiries, students have to be intellectually socialized to expand and augment their cognitive resources by deliberately working at external memory fields and writing for creating knowledge. As a social practice, writing is mediated by literate genres, i.e., socially and culturally recognizable, ritualized, and repeated production of typified epistemic artifacts in human collectives (Bazerman, 1988; 2004; Prior, 1998). Beyond genres of reporting textbook knowledge, the participants of technology-mediated learning have to learn to master academic writing focused on using writing as a tool of extending their thinking and deliberately generating new ideas and working theories. Epistemic mediation appears both to require and assist formation of a specific kind of identity as a prospective builder and creator of knowledge.

Bereiter and Scardamalia's knowledge building framework aims at making a Copernican revolution in education in terms of putting student-generated ideas at the center of education. When engaged in collaborative knowledge building, students are, in a very concrete way, engaged in working with imagined and anticipated objects that materialize and take their shape only after sustained collaborative efforts forcefully constrained by requirements of reaching coherent understanding or creating a functional product. Such open-ended objects appear to generate constantly novel questions and become more and more complex when pursued:

Objects of knowledge appear to have the capacity to unfold infinitely. They are more like open drawers filled with folders extending infinitely into the depth of a dark closet. Since epistemic objects are always in the process of being materially defined, they continually acquire new properties and change the ones they have. But this also means that objects of knowledge can never be fully attained, that they are, if you wish, never quite themselves. (Knorr-Cetina, 2001, p. 181).

Technology-mediated learning environments and corresponding practices provide valuable resources for knowledge-creating inquiry in terms of assisting in building on, synthesizing, and rising above epistemic artifacts created. It appears that CSCL environments are children of hybridization in terms of providing material technology for sustained working with shared digital (but materially embodied) artifacts. Such knowledgeware technologies and associated practices of knowledge building allow working with distributed epistemic artifacts, and, thereby, elicit collectivization of inquiry and learning. Integrating CSCL technologies as instruments of one's activity is a developmental process in its own right; cultivation of innovative inquiry practices within a learning community is not possible without sustained iterative and expansive efforts at creating an adequate chronotope. Hence, technology enhances learning only through transformed social practices.

### **Understanding Knowledge Building as a Small-group Cognitive Process (Stahl)**

Knowledge building, whether carried out in classrooms, laboratories, or businesses, is almost always carried out in small groups. Accordingly, understanding it requires a theory appropriate to the level of small-group phenomena. The theory of group cognition (Stahl, 2006) stakes out the domain of group meaning-making processes as a new domain for scientific inquiry. Importantly, it distinguishes this domain from the traditional

domains of sciences of individual learning and of the development of social practices in communities.

The move from the individual to the group level of description as foundational entails an important philosophical step: from cognitivism to post-cognitivism (Stahl, 2011). Although the literature on small groups and on post-cognitivist phenomena provides illuminating studies of the pivotal role of small groups, it does not account for this level of description theoretically. In the final analysis it is almost always based on either a psychological view of individuals or a sociological view of rules, etc., at the community level. None of the studies has a foundational conception of small groups as a distinct level. They confuse talk at the group level and at the social level, and they lack a developed account of the relationships between individual, group and community.

If we take group phenomena seriously as “first-class objects,” then we can study: interpersonal trains of thought, shared understandings of diagrams, joint problem conceptualizations, common references, coordination of problem-solving efforts, planning, deducing, designing, describing, problem solving, explaining, defining, generalizing, representing, remembering and reflecting as a group. The VMT (Virtual Math Teams) Project was designed to explore the phenomena of group cognition and accordingly pursued the research question:

How does learning take place in small groups, specifically in small groups of students discussing math in a text-based online environment? *What are the distinctive mechanisms or processes that take place at the small-group level of description when the group is engaged in problem-solving or knowledge-building tasks?*

While learning phenomena at the other levels of analysis are important and interact strongly with the group level, we have tried to isolate and make visible the small-group phenomena and to generate a corpus of data for which the analysis of the group-level interactions can be distinguished from the effects of the individual and community levels (Stahl, 2009). The design and continued enhancement of technology to support small-group meaning making was in response to emergent findings about the strengths and difficulties of these interactions. Research to date makes clear that rigorous and progressive research can be carried out on cognitive processes at the group level and that such research can contribute significantly to both the conceptual and technological development of knowledge building.

### **Improvable Ideas: The Foundation of Knowledge Building (Scardamalia & Bereiter)**

Sophisticated people in any modern field—the people Robert Reich categorized as “symbolic analysts”—recognize the progressive nature of knowledge in their field. They recognize that the designs, tools, procedures, theories and even the core assumptions underlying their work are continually subject to change and improvement. Ensuring that tomorrow’s ideas are better than today’s is an implicit part of most “good” jobs. In a larger sense, it is civilization’s main hope for solving the grave problems that beset it. Not only technical solutions but social, economic, political, and personal solutions call for breakthroughs in knowledge. Innovation is the new normal—“part and parcel of the ordinary,” as Peter Drucker (1985) said—rather than a departure from the normal, as it was in previous generations. Yet schools seem to be preparing students for a world that preceded not only the current “knowledge age” but the 19<sup>th</sup> century “age of invention” as well. We are preparing them for a society in which progress depended on “the occasional happy thought,” as Whitehead put it. Efforts to promote creativity as a “21<sup>st</sup> century skill” are grounded in an obsolete ideology; they are aimed at increasing students’ ability to produce “the occasional happy thought.” Whitehead (1925/1948), however, saw the 19<sup>th</sup> century as having achieved the professionalization of invention, the practice of bringing knowledge to bear on the deliberate creation of new knowledge.

It is not just traditional education, with its emphasis on knowledge transmission and skill practice, that falls short of preparing students for today’s world. Educational standards, even the newest ones, fail to lock on to the knowledge-creating dynamic that characterizes progressive organizations, professions, and disciplines. Science standards call for familiarizing students with the uncertainties of empirical knowledge. Hypothesis testing and evidence-based argumentation figure prominently, but we see little that would acquaint students with how knowledge advances are actually made—how fruitful hypotheses are generated and how they are developed and improved to emerge as a full-blown inventions, designs, plans, theories, organizations, or works of art. Research by Windschitl (2004) has indicated that teachers themselves typically do not understand how science progresses beyond the accumulation of tested findings.

Naïve realism views scientific progress as the unproblematic accumulation of facts, but it is only one step up to view it as the problematic accumulation of uncertain empirical conclusions. That is movement from level 1 to level 2 in Carey and Smith’s (1993) scheme. Level 3, at which science is viewed as a creative explanation-seeking enterprise lies beyond, and is evidently seldom reached in school science.

To the extent that this limitation extends to the whole curriculum, it indicates a serious deficit in education’s ability to prepare students for the 21<sup>st</sup> century. Responsible education of all kinds strives to improve students’ ideas. But educating students to be idea improvers is another matter, and this is where contemporary



education seems not only to fall short but not even to recognize there is a problem. Since there are no tried and true ways to achieve this objective, our best bet is to engage students as fully as possible in the activity itself—sustained, collaborative, creative work with ideas. That, in essence, is what Knowledge Building aims to do.

Most constructivist educational approaches engage students in collaborative work, often sustained for longer periods of time than is typical in school curricula; sometimes it involves creative production (especially the production of media objects); and the most intellectually serious kinds strive to bring students into contact with the “big ideas” of the disciplines. So what is distinctive about Knowledge Building? It is focusing the sustained, collaborative, creative work on ideas themselves and their improvement—not on the representational media, not on the “scientific method” or its counterparts in other disciplines, not on the social structure and dynamics of classroom activity, but on ideas. All these other facets of scholastic life are important and warrant support, but they are subordinated to the goal of helping students become agents rather than only beneficiaries of idea improvement.

Idea improvement is a relatively modest goal, one that students can feel is within their competence, whereas dangling the models of Einstein and Darwin before them is likely to intimidate all but the boldest few. When we speak of idea improvement we do so in full awareness that “conceptual revolutions” (Thagard, 1992) may be needed when a theory or idea has reached its limit of improvability and needs to be replaced by a radically different one. Radical shifts are often required in students’ conceptual development because their original idea (for instance, that up and down are absolute directions independent of gravitational field) quickly reaches its limit of improvability and must be replaced by a more fruitful concept. However, we propose that *as a working assumption* all ideas should be treated as improvable. This assumption encourages not only a skeptical attitude toward truth claims but also a constructive attitude, which favors preserving and building on the strengths of an idea rather than rejecting it out of hand as soon as it is discovered to have a flaw. Furthermore, common usage allows even radical changes to be called improvements. Thus, relativity theory is treated as an improvement over Newtonian physics, because it does not explicitly repudiate Newtonian physics but assimilates it into a larger conceptual framework. That kind of “rise above” improvement is especially germane to students’ conceptual development and is something that a knowledge-building approach should promote.

It goes almost without saying that idea improvement, insofar as it involves movement from simpler to more complex ideas, is necessarily a self-organizing process. Self-organization is the only viable explanation of how growth in conceptual complexity is achieved (Molenaar, 1986). This is true even when the more complex concept is supposedly conveyed by a lecture or a text: grasping it requires constructive activity on the part of the learner that is equivalent to theory building (Popper & Eccles, 1977, p. 461). But when, as in knowledge building, the students are agents of their own production of more complex conceptual structures, the demands put on a sustained self-organizing process are likely to be greater. The greatest challenge for knowledge-building technology, accordingly, is to support a self-organizing process in the realm of ideas. This is something beyond supporting self-organization at the social level (which the new social media seem to be accomplishing to amazing effect) or self-organization in the planning and conduct of projects (which is the province of project management software and educational adaptations of it).

The approach we are advocating in designing next-generation knowledge-building software is to treat ideas rather than people or actions as the units in a self-organizing system. Social networks evolve and projects and processes evolve. All of these warrant feedback systems to support their evolution. But it is the evolution of ideas that occupies center stage and that these other kinds of evolution subserve. Thus we want to build idea network analysis, comparable to social network analysis; nearest-neighbor searches that identify neighboring ideas, even if they are located in different parts of a database; and ways for students’ judgments of promisingness and importance and for their metacognitive awareness to feed into the process of idea evolution. Knowledge-building dialogue is key, for advances in community knowledge are not merely supported by dialogue but actually take place in it (Tsoukas, 2009). Among other well-known advantages of having discourse carried out online is the fact that it produces something semantic analysis tools can work on and hopefully provide feedback of a kind that will enhance the self-organizing processes of conceptual evolution.

These proposals are in line with a current trend to design self-organizing networks (Rycroft, 2003), whether Internet-based or not. They are at the opposite pole from threaded discourse, which seems almost to have been designed to thwart self-organization—or, at its worst, to thwart organization of any kind. They also stand in contrast to clickers and related kinds of response technology, which can be used in a variety of educationally beneficial ways but which keep the teacher in control of the information flow. Whether idea-centered knowledge-building technology can take advantage of Facebook and Twitter kinds of technology is a challenge yet to be explored. The challenge may be framed as “sustained creative work with ideas meets short attention span.”

## “Design Mode” As the Essential Mode of Thought in Knowledge Building (Bereiter & Scardamalia)

A distinction between *belief mode* and *design mode* (Bereiter & Scardamalia, 2006) helps to define what is distinctive about knowledge building. Belief mode is and always has been the prevailing mode of formal education. It deals with the question, “What shall we believe?” The methods of dealing with this question have varied considerably over the years. Indoctrination marks one extreme, critical inquiry the other. Modern education generally favors critical inquiry, with an emphasis on evidence and logical reasoning, along with openness to opposing beliefs. Belief mode discourse almost invariably involves argumentation. The argument may be one-way, as in lecturing or sermonizing, or multi-directional, as in a class discussion; but in any case belief mode discourse is characterized by efforts to persuade.

One can read whole books on curriculum issues and classroom methods and never get an inkling that there could be any way of dealing with academic subject matter except through some variation of what we have just described as belief mode. Yet out in the “real” world, most productive thinking is carried on in a quite different mode. It is *design mode*: the mode of problem solving, invention, planning, and other creative knowledge work. In belief mode, key questions to ask about any proposition are “What are the arguments for and against?” and “What does the evidence show?” In design mode, the most challenging questions are “What is this idea good for?” and “How could this idea be improved or further developed?” These are questions almost never addressed in education, except at the highest university levels.

Both belief mode and design mode are important in knowledge building. Issues of truth and belief inevitably arise. The interactions between belief mode and design mode activity can be complex and are sometimes problematic. Our main point, however, is that design mode could be playing a much more significant role in education than it does now. Design mode does find a place in schools, but it tends either to lie outside the formal curriculum or to take the form of exercises. Putting on a play involves a lot of design work. Planning a trip to Mars, a popular “constructivist” activity in elementary schools, exemplifies design mode work as an exercise. But all *serious* academic work—work with important disciplinary ideas—goes on in belief mode. That is how it was with Socrates and his students, that is how it was in the medieval *sic et non*, and that is how it is in the present-day “thinking curriculum,” even in its most epistemologically liberated, social-constructivist, and “postcolonial” forms. Even in inquiry-based or “hands-on” science education, the modal experiment is one that confirms or disconfirms a hypothesis (that is, a tentative belief). The actual construction and refinement of a coherent explanation of observed phenomena finds little or no place in the curriculum. Knowledge Building brings design mode into the heart of the curriculum, into the part that deals with core disciplinary knowledge.

A concrete example of fourth-graders operating in design mode is discussed by Zhang, et al, (2009). In the course of studying about light, children began to raise questions about rainbows. The initial answer they got from authoritative sources was the standard one that attributes rainbows to water droplets acting like prisms (they had already experimented with prisms). The students posed further questions arose, however, that took them deeper into the physics of rainbows: How could such a big thing as a rainbow be produced by tiny water droplets? Why are the colors of the rainbow always in the same order? Why do rainbows always take the shape of a semicircle? Students proposed theories to answer these questions and refined their theories on the basis of experimental and authoritative information. Scientifically adequate answers to these questions, such as could be found in *Wikipedia* and the websites of scientific organizations, required mathematics well beyond their level. But the qualitative theories the children did develop compared favorably to the information provided by school-oriented web sites and were superior to some of those that popped up first in a web search (Bereiter & Scardamalia, 2010). The common belief-mode question to arise in this kind of situation would be “Is this theory true?” The children were not indifferent to this question, but the design-mode question that drove their inquiry was the much more sophisticated one: “Does this theory explain the facts?”

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# Integrated Tool Support for Learning through Knowledge Creation

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**Abstract:** In this symposium we discuss pedagogical design involving technology that aims to support and foster learning through object-bound collaboration. The designs employed have emerged from the knowledge creation approach (Paavola & Hakkarainen, 2005), which depicts learning as a collaborative activity aimed at creating shared knowledge objects. Technology-mediation has a prominent role in supporting collaboration processes, iterative development of products, and reflection of knowledge practices. The KPE environment (<http://www.knowledgepractices.info>) is an integrated, modular open source software. It is designed to enable various visual views on the collaboration process and the related knowledge practices. In this symposium we present four empirical studies that examine ways of supporting higher education and professional learning, and learning through development of knowledge objects (e.g., designs, software applications, research reports). The four research studies attempt to explain how the different functionalities of the KPE can enhance collaboration and development of shared knowledge objects.

## General Introduction

In this symposium we will present and discuss pedagogical design involving technology that aims to support and foster learning through object-oriented collaboration and knowledge creating inquiry. The aim of the symposium is to understand how the participating students, teachers, and professionals engage in knowledge work and the development of shared knowledge objects with the technology-mediation provided by the Knowledge Practice Environment (KPE). The KPE is a Web 2.0 application that provides participants with integrated tools. Activities supported by the integrated tools are, for example, co-construction of knowledge, collaborative and iterative writing, conceptual modeling, and reflection of knowledge practices (Lakkala et al., 2009). The four research studies presented in this symposium attempt to present an integrated investigation approach, and to explain how the tools and functionalities of the KPE environment can enhance and support different aspects of the aforementioned activities.

In the current knowledge society many problems are of an open-ended character. To solve such open-ended problems collaboration both in groups, but also across groups, with various expertise is a presupposition. In current work practices, multi-professional collaboration is typically organized around long-term efforts for developing shared, tangible knowledge objects such as products, models, articles, or practices (Paavola & Hakkarainen, 2005). In the educational system, this creates a challenge for design of the curriculum and tasks: on the one hand learners should develop systematic understanding of their specific knowledge domains, and on the other hand they should develop expertise that prepares them for taking part in work life processes around the development of complex epistemic objects (Knorr-Cetina, 1999; Miettinen & Virkkunen, 2005). Designing for knowledge creation calls for a new mindset for educational institutions and educational activities. To promote such changes is a long term effort. The EU-funded project “Knowledge Practices Laboratory” (KP-Lab) is a response to the described challenge. The KP-lab project now entered into its last phase, and we can present empirical findings and reflections on the theoretical foundations, and the pedagogical and technological design.

One of the leading ideas in the project has been to explore how theoretical claims put forward by the knowledge creation approach to learning (Paavola & Hakkarainen, 2005) can be materialized in the educational practice and, consequently, what are the implications for pedagogical and technology design. The knowledge creation approach has its origin in Bereiter and Scardamalia’s work (2003) on expertise and knowledge building communities, while the object-orientation builds on the ‘turn towards objects’ in activity theory (Engeström, Miettinen, & Punamäki, 1999). The knowledge creation approach emphasizes epistemic and pragmatic dimensions of object-oriented inquiry and technology-mediated collaboration in social practices. It depicts learning as a collaborative activity aimed at the creation and advancement of knowledge objects by making use (work with, manipulate, modify) of various kinds of artifacts. In these processes, individual and collaborative

learning are seen as intertwined. The knowledge objects convert joint idea development and knowledge creation efforts into resources that can be re-used and modified in new learning and working contexts.

The theoretical claim underlying the knowledge creation perspective is that new meaning and understanding of the domain arises through the externalization of knowledge and collaboratively creating knowledge objects that emerge and become transformed over time. In the knowledge creation approach an explicit theoretical account of the social interaction is included, which was not theoretically accounted for in the knowledge building approach (Ludvigsen, 2009). The mediated nature of human activity (see Vygotsky, 1978) is acknowledged in the knowledge creation approach particularly by emphasizing multiple types of technology-mediation; including support for pragmatic, social, epistemic, and reflective types of activities (Lakkala et al., 2009; Paavola & Hakkarainen, 2005; Rabardel & Bourmaud 2003). In this context, technology plays an important role as a mediating element, since it enhances the social interaction between participants and (shared) knowledge objects, and the development of innovative knowledge practices.

The added value of KPE is in the integration of various functionalities to build a multipurpose and flexible collaborative virtual environment, which is designed to support complex activities, both at the epistemic and procedural levels. In KPE, individual and collective shared (work) spaces can be created, e.g., by a project team, students attending a class or members of a multifunctional development team in an organization. Different visualizations are possible: a view of the *process*, a view of the *content*, a *community* view, an *alternative process* view, and a *tailored* view. Within these views KPE focuses on supporting the sustained activities around shared objects through offering flexible tools for: a) joint elaboration, versioning and visual organization of content; b) object-bound commenting and chatting; c) use of semantics in content specific searching, conceptual modelling, tagging, and explicating relationships between various knowledge items; d) awareness of other users' participation and status in knowledge creation processed supported by KPE, and e) management and organization of the groups' practices (see images in Figure 1). KPE also provides analytic tools for automatic analysis of collaborative work and development of shared objects. The analytic tools offer possibilities for students, teachers, and researchers to visualize and reflect on the knowledge creation processes and provide reference points for practice transformation.

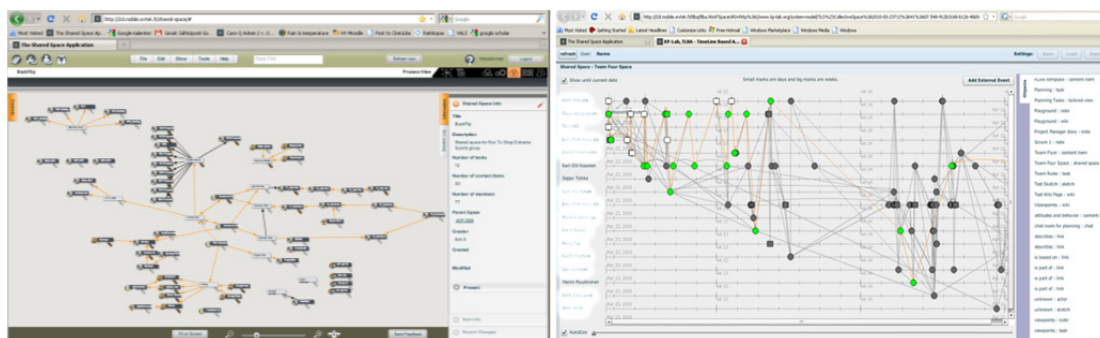


Figure 1. Screenshots from the KPE: Left the Content View; Right the Timeline-based Analyzer.

In the four cases, we examine ways of pedagogically designing and supporting higher education learning and teaching activities, and professional practices where participants develop knowledge objects (designs, software applications, research reports). Three themes are taken up by the presentations: collaborative and iterative development of knowledge objects, conceptual modeling, and identifying patterns of collaborative object-oriented inquiry. The symposium setup stimulates interaction between the presenters and the audience by 1) presenting the findings of the research studies, 2) depicting the tools and functionalities employed and 3) by inviting discussion focused by these three themes. We will provide a brief introduction to the symposium and then organize the presentations and the discussion around the aforementioned themes. We intend to engage the audience in the discussion of the contributions, using the three themes to structure the interaction.

## Iterative Co-construction of Knowledge Objects by Student Teachers

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### Introduction and Theoretical Considerations

In this contribution we investigate how teacher students work in collaboration to create and develop knowledge objects that will be employed at their internship places. We examine the processes revolving around collaborative and iterative knowledge object development and the way student groups employ features of technology designed to support this type of activities. We focus on identifying collaborative mechanisms across

groups and we provide a more detailed insight into how knowledge objects are developed by a number of groups.

Exposing students to knowledge practices they will perform as professionals seems to be a challenging task in higher education. In this study, the prevalent idea in the KP-lab project is that problems with an open-ended character entice students to engage with knowledge and make their own knowledge explicit. This involves theoretical and practical knowledge being materialized into objects (e.g., in educational material, evaluation instruments, research reports, etc.), where this knowledge becomes transparent for the participants involved. Nevertheless, becoming actively involved and successful in such complex processes, and creating sophisticated knowledge objects, is a challenging task for students. The knowledge creation approach to learning (Paavola & Hakkarainen, 2005) can serve as a guide to develop new practices of learning and instruction, which places collaborative creation of knowledge objects at its core. Knowledge creation processes not only shape the knowledge objects constructed but are also transformed by the actions that are performed on these objects (Stahl, 2006). Pedagogical designs should explicitly scaffold these practices through incorporating collaborative co-construction activities revolving around knowledge objects. This involves also providing various types of technological support. Whilst various studies showed how (online) technology features enhance dialogic interaction for learning (see for a review Ludvigsen & Mørch, 2010), technology that supports interaction through knowledge objects received less attention.

### **Empirical Setting, Methods and Data**

This one-year study was conducted at a University of Applied Sciences and Teacher Education in the Netherlands that prepares teachers for lower secondary education. The curriculum is based on Professional Situations (PS) wherein students are stimulated to mobilize knowledge and skills during projects conducted at their internship schools. Twenty groups formed from 73 mixed-age students, enrolled in three randomly selected PS's, participated in the study. Learning was enhanced by participation in collaborative knowledge creation activities, where groups of students developed and reported on authentic knowledge objects, such as didactic materials, guidelines or manuals for teachers. Supporting activities and materials were provided, such as workshops on object-oriented collaboration, document templates with topics for work plans, and training sessions for using KPE (for both teachers and students). In the KPE, each group had its own shared workspace. Inside these spaces, students were expected to employ functionalities that supported organization and management of the collaborative process (i.e., task creation and planning functionalities) and iterative development of knowledge objects (i.e., versions, commenting, sources display through web links, linking and chatting). We collected a rich set of data, consisting of: a) interaction data; b) knowledge objects, and c) reflection data. The analyses include frequencies of individual contributions to the collaborative work, coding of groups' interactions, and a detailed analysis of knowledge object development and iterations by one group.

### **Findings**

Results indicate that groups employed different strategies to organize their work – division of labor was frequent. In terms of object development, there are a number of aspects that stand out. Co-construction moments occurred in some groups' work, such as discussing ideas and concepts, and then following up and materializing these ideas into object iterations. Elaboration of object sections was often done individually, and the outcomes were placed in the group's shared space, where the other group members could read it and provide it with feedback. However, some groups had difficulties to collaboratively expand their knowledge on the matter and to build on it together, or to concretize this knowledge into the objects in-progress. Most recurrent situation in these groups was that ideas were discussed but not taken-up and not materialized. In these groups, mutual feedback and revisions on iterations of the objects were less common. Of the 20 participating groups 17 used the shared work spaces provided in KPE. Groups that employed co-construction strategies registered were also registered to be most active in using KPE, and received a positive final assessment of their final product by their tutor. Majority of groups used the shared spaces to store and organize their knowledge objects. Twelve of the groups used the Process view and task creation functionalities to plan and organize their collaboration, and reported on these functionalities as being good support for this purposes. The types of items mostly created were document files, web links (to online sources), and comments on document versions. Twelve groups used the system to visualize versioning of their knowledge objects, and indicated this functionality as supporting well the work on the knowledge object. These results show that most students became engaged in co-constructing shared knowledge objects, but individual elaboration and strict division of labor without much feedback on object iterations occurred too.

To conclude, the study indicates that the challenging task of managing and constructing knowledge objects and the use of complex web-based technological support suits students who are able to employ productive strategies, but that other students need more intensive support. Hence, these findings call for attention to students' understanding of this pedagogical setting and of technology; also, to how these types of designs can provide more clear scaffolds for students when entering the knowledge co-construction process.

Furthermore, more focused studies are needed especially on how tools can support collaborative elaboration of textual objects.

## **Modeling Professional Practices and Object-bound Knowledge Creation in a Higher Education Customer Project**

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### **Introduction**

The rapidly evolving knowledge practices of present professional settings generate novel demands for education. The knowledge creation approach to learning (Paavola & Hakkarainen, 2009) provides theoretical background to address learning and teaching organized around authentic problems and the development of shared knowledge objects, such as reports, products, and new practices. This approach focuses on the development of shared objects in addition to the pursuit of personal learning and collaborative discourse interaction.

The study examines a higher education course which involved students, teachers, and customers in a complex tryout of knowledge creation. Multidisciplinary student teams from three degree programs, media engineering, industrial management, and communication, were asked to develop a business idea and make it happen for real. Teachers from these degree programs and customers from four companies were participating in the process for six months. Students were provided with various analytical, reflective and managerial documents (Omicini & Ossowski, 2004) that functioned as templates. The documents were intended to promote professional practices and object-bound knowledge creation (Eckert & Boujut, 2003; Paavola & Hakkarainen, 2009). We investigated how these documents (e.g., status report, customer presentation template) and related guidance (specifically during steering group meetings) from teachers and customer representatives contributed to student teams' advancement. The advancement was expected to manifest itself in the produced business ideas and plans, user stories, and mock-ups as well as in the management of workflow and project reporting, creation of functioning technical solutions, and communication with potential end-users. Further, we examined how the various collaboration tools were used and what kind of mediation for joint activities they provided.

### **Research Methods**

A total of 50 students from 3 study programs of the Helsinki Metropolia University of Applied Sciences participated in the course for 6 months. The Knowledge Practices Environment (KPE) software was used as the shared environment, but student teams utilized several tools for their teamwork (e.g., GoogleDocs and Dropbox) in parallel. The course was one of the Finnish test sites in the EU-funded Knowledge Practices Laboratory project (see <http://www.kp-lab.org>).

From the originally 11 student teams, 5 teams that most actively used the KPE environment were examined. In addition, 2 teams were randomly selected for an intensive follow up at the onset of the course (one team included in the former analysis). The following data were collected: video recordings of teacher and customer guidance during weekly steering group meetings from the two intensively followed teams, as well as weekly self-reports on project advancement and KPE data on the versioning of central knowledge objects from all teams. Interviews with teachers, and the students and customer representatives of the 2 teams were conducted at the end, including questions about the use of collaboration tools, team functioning, and the advancements of team productions.

Qualitative data analysis of the video recorded steering group sessions was carried out to examine what the mentoring focused on. A second qualitative content analysis focused on the progress reports and major editions found in the project documentation. The results of these two analyses were compared to gain an understanding of how the comments were observed to influence the iteration of knowledge objects. Further, a thematic examination of the interviews provided evaluations of the strengths and weaknesses of the course design, the tools used, and reflections on the process and its outcomes.

### **Findings**

The templates provided a starting point for project documentation. Teams faced difficulties related to focusing their business plans and coordinating the engagement of students from multiple domains. The customers and teachers facilitated especially turning attention to the end-user needs and explaining team's ideas to potential clients of their business solution. Successive versions of the business ideas and software applications could be observed to undergo considerable changes based on work on the intermediate documents and related guidance. Overall, 3 teams accomplished all the steps involved in designing and implementing an application and engaging clients for their business. Most other teams accomplished either the application or acquiring the client.

KPE was found to mediate participants' epistemic and regulative actions. Such functionalities of KPE as uploading files, and creating notes and links were mostly used to organize work around the documents and

their subsequent versions (epistemic mediation). Several functionalities were found to serve regulative purposes (pragmatic mediation): creating tasks and links between them; the object-bound chat tool; and the note editor for creating meeting memos and defining team members' roles and responsibilities.

### **Theoretical and Practical Implications**

The findings suggest that the teams were faced with demands for efficient practices in analytical business procedures, work flow management, and coordination and communication with the customer representatives and potential clients. Similar collaboration and knowledge creation challenges have been reported in relation to global virtual teamwork in professional practices (e.g., Faraj & Sproull, 2000). The use of KPE provided epistemic and pragmatic mediation by allowing the student teams to organize their tasks and show visually interdependencies of documents and their iteration.

### **Making Use of Artifacts in Processes of Object-bound Inquiry**

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### **Introduction and Theoretical Considerations**

This contribution focuses on creating and utilizing artifacts in processes of object-bound inquiry. We investigate how project teams create and make use of various kinds of artifacts in order to solve complex design task and how their utilization is shaped by the properties of the artifacts chosen.

Even though the importance of shared artifacts for learning and knowledge creation has been stressed by various scholars (e.g. Stahl, 2006; Bereiter, 2002) and is also at the core of the KP-Lab project, the affordances and materiality of different kinds of artifacts in processes of object-bound inquiry has hardly been investigated yet. While shared artifacts have been studied as means for grounding and coordination of collaborative efforts, their potential role as objects of joint exploration and inquiry is only poorly conceptualized and understood. Building on the work of Gedenryd (1998) and Knuuttila (2005) we conceptualize artifacts as dynamic entities, which can fill multiple roles depending on the type of activity they are used in, while yet being constrained by their material and sign-related properties. Rather than treating artifacts as mere representations or carriers of information and ideas, we are particularly interested in their material and sign-related qualities with regard to fostering and impeding their utilization for epistemic processes. From a pedagogical perspective artifacts are particularly interesting as they provide important means to scaffold and support but also to monitor learning processes. Therefore a better understanding of the properties of artifacts and their utilization for different activities can provide for better guidance in the complex endeavor of object-bound inquiry.

### **Empirical Setting, Methods and Data**

This study was carried out in a project-based course at the University of Applied Sciences in the bachelor program "Communication and Knowledge Media". In a compulsory first-year bachelor course, project teams of 3-6 students were asked to develop an educational scenario drawing on existing web 2.0 technologies. The course was meant to promote an understanding of design as a process of object-bound inquiry. All in all 26 students in 8 teams took part in the study. To support the design process students were introduced to Knowledge Practices Environment as well as a variety of techniques and design artifacts to document their understanding of the design space at stake. Typical design artifacts included journey frameworks, conceptual models of the designs space, various types of prototypes for probing as well as reports.

The set of data used for this study consists of: a) project-logs on students' activities filled in by each team, b) periodic interviews with the teacher on her intentions and experiences with the different interventions, c) retrospective group interviews with each team at the end of the course, d) log files from KPE and VME, e) artifacts and documents uploaded or linked to KPE. The analysis is focused on the contents of the various artefacts and the kind of activities they were created in and used for.

### **Results**

Even though the design task and instructions have been the same for all groups, we found considerable differences in the overall flow of activities and in the utilization of the design artifacts. While most of the teams apparently worked in a rather linear fashion, basically refining and building on their initial ideas, two teams revised their initial ideas significantly in the course of their project. Comparing the contents of the different artifacts produced by each team, we found that the conceptual overlap across artifacts was often rather low, even for those artifacts submitted as project results. This finding seems to indicate that the students conceived the artifacts indeed as complementary, fulfilling different functions. With regard to the different types of artifacts introduced by the teacher we found differences both between teacher's intentions and actual use but also between the different teams. While for example the teacher's intent for using conceptual models had been to



foster articulation and scrutinizing of students' assumptions, the models were rather used as means for documentation. Comparing the prototypes created by the teams we found them to be used as means to describe and communicate ideas on the user interface level, to explore different design options but also to test for usability problems and probe experiences. The way the artifacts are used appears at least partly due to the particular kind of material and format chosen.

Tool use turned out to be heavily dependent on the actual tasks at hand. While the KPE was primarily used to collect, document, and organize, links, notes, and documents, as well as to create visual models of the design space, most other artifacts were created by third party tools such as Indesign, MS Word and Excel but also pen, paper and scissors to create prototypes. It is obvious that students like to use flexible tools such as Word and paper-based notes, as they can easily edit, reuse, and share the artifacts created.

### **Theoretical and Practical Implications**

The results of this study suggest, that processes of object-bound inquiry draw on a multiplicity of artifacts each of them providing unique affordances and constraints. Besides its content, the epistemic use of an artifact is also shaped by its material and sign-related properties. From a pedagogical perspective it appears important to be sensitive to the way these artifacts are appropriated by the students and the actual purpose(s) they are used for. From the perspective of tool development, these findings point to a major limitation of collaborative learning environments currently available. While existing collaborative learning environments usually provide a broad array of functionalities to share, comment, and trace resources as well as documents, they are often quite restricted in their capability to collaboratively create and work with artifacts beyond text, conceptual models and or simple sketches.

## **Using the Knowledge Practices Environment (KPE) to Support Collaboration in a Systems Development Project at a Hospital**

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### **Introduction**

The knowledge creation approach to learning has a particular interest in collaborative knowledge creation processes in which concrete artifacts and practices ('knowledge objects') are created and developed. The roles of external representations in mediated discourses have been studied extensively in research areas such as CSCL, e.g. (Rogers et al. 2002); CSCW, e.g. (Scaife et al. 2002); and distributed cognition, e.g. (Hutchins 1999). Artifacts have varying roles in collaborative work processes, and perhaps especially so in design and development teams. The meaning of design representations are not carried by artifacts (such as sketches) themselves but are made meaningful through accompanying design activities (Tholander et al. 2008).

The project under study concerned a systems development project, focusing on the creation of a new medical information system at a large hospital. The project explored and suggested new solutions for collecting and presenting data about patients and treatments. The core team consisted of an IT specialist, a physician, two nurses from different clinics and a researcher (KK). The hospital's management, represented by the CEO and three head doctors, also took part in some meetings. The team met monthly over a 12-month period. Early interviews with each project member revealed that existing project tools and practices were considered unsupportive or constraining; good ideas produced during meetings were often forgotten, not pursued between meetings, and ideas were systematically dependent on particular individuals, e.g., documentation was kept on individual members' computers, resulting in a lack of collaborative elaboration. Moreover, planning and coordination of work was typically driven by factors external to the project rather than based on the development of new ideas deriving from the team. With these problems as a background, and based on 'work-pedagogical' ideas of fostering knowledge creation practices, the Knowledge Practices Environment (KPE) was introduced into the project. The team members were given training and the project had a "shared space" in KPE. An aim was to manage the flow of project information and tasks, and to see their mutual dependencies. The members had equal rights to create, modify, comment, and delete items. The space was organized to include project tasks, the relevant project documents, and items to support documenting and commenting of ideas. Dependencies were marked by linking tasks, items and persons.

### **Aim, Methods and Analyses**

The aim of this study was to examine the roles of KPE in supporting the knowledge creation processes of the development project. A rich set of data was collected: reflective data through interviews, interactions at meetings (video recordings), and artifacts stored in KPE. For analysis, a protocol for exploring tool-mediated knowledge creation processes was used consisting of three dimensions: epistemic (e.g., elaborations, creating awareness), regulative (e.g., planning, organizing) and transformative (e.g., formalizing collaboration).

## Findings

KPE was primarily used during meetings for structuring various items, e.g., tasks, ideas, background material, reports, notes, comments, sketches, links, and pictures of whiteboard notes. Between meetings it was used mainly for catching up, uploading materials, and sometimes for commenting. KPE was projected on a large screen and its contents referred to in the discussions. KPE had a central role of giving an overview of materials that were produced and collected and supporting reflection and planning of further work. Team members asked for items to be stored in KPE to make them available for all and sometimes explicitly asked for comments.

KPE served an awareness-creating role by reminding of previously discussed ideas and uploaded materials and showing participants' contributions, supporting the elaboration of items. The risk of ideas being left unattended to was lowered. During meetings whiteboards, pen and paper were also frequently used and sometimes the results were photographed and uploaded to KPE. Planning and organizing collaboration was done in the Process view by creating tasks and linking them to individuals. KPE thus had a regulative function; having the tasks presented reminded of tasks still to be done or information that needed to be collected. Conversely, KPE also served an awareness-creating role by reminding and bringing into focus already carried out tasks but which had not been reviewed in the meetings. Participants expressed that the team's planning became more prominent and directly connected to the specific objects/tasks that were currently worked on. KPE's functionality for presenting events that can be followed on a timeline as work progresses (Timeline Based Analyzer) was occasionally used to get an overview of progress in the project. KPE's abilities to provide overviews of work 'at a glance' were appreciated. However, moving between items in different parts of the system was considered challenging. The degree to which material was uploaded or tasks were defined for users in KPE varied between participants.

## Theoretical and Practical Implications

KPE served a regulative function in planning further work, channeled the joint discussion, helped documenting new ideas, and had an awareness-creating role by representing what had been done and reminding of planned tasks. KPE thus appeared to in part resolve some of the pre-existing problems hindering knowledge-creation processes. Between meetings individual users would not use the tools extensively which may in part be explained by usability challenges. Also, there were individual differences as to how much material and tasks were posted - knowledge creation practices do not develop automatically by introducing KPE – and an implication for development projects is to carefully consider and explicitly decide on strategies and routines for documenting work and managing tasks in order to get the most of a system supporting collaboration.

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## How Can Current Approaches to the Transfer of Technology-Based Collaboration Scripts for Research and Practice Be Integrated?

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**Abstract:** Research on technology-based collaboration scripts has been very successful in terms of the development of a broad range of scripts that effectively foster processes and outcomes of computer-supported collaborative learning. However, neither the transfer to other experimental platforms nor the transfer into practice has been managed systematically so far. To foster both replications of script effects across domains and sites and the use of scripts of proven effectiveness in practice, tools that allow for the exchange of scripts are necessary. This symposium offers an overview of the most influential tools to develop, implement, investigate and transfer computer-supported collaboration scripts. Furthermore, the future direction of the development of tools for script implementation and transfer is discussed.

### Why We Need More General Tools for Script Development and Implementation

Research on technology-based collaboration scripts has been very successful in terms of the development of a broad range of scripts that effectively foster processes and outcomes of computer-supported collaborative learning (e. g. Baker & Lund, 1997; Weinberger et al., 2005; Kollar et al., 2007). One goal of this research is to reveal the mechanisms or types of successful scripts and to formulate guidelines for the development of effective computer-supported collaboration scripts. However, the accumulation of findings about general script mechanisms or types is quite difficult due to the fact that all these scripts were developed for a variety of instructional scenarios, learning environments and educational institutions. Technology-based collaboration scripts are usually tested exclusively within one of these environments. Neither the transfer to other experimental platforms nor the transfer into practice has been managed systematically so far.

Why is it a problem that specific technology-based collaboration scripts hardly are used across different (experimental) platforms? We need evidence to what extent script effects can be replicated across instructional scenarios, learning environments and educational institutions. Evidence is needed whether script effects be specific to the instructional scenarios, learning environments and educational institutions in which they were tested or whether they have rather general effects across different integrations. However, it is common practice to generalize over different instructional scenarios, learning environments and educational institutions despite the fact that the script was only tested in one environment. To overcome this problem, the effectiveness of particular scripts needs to be established across a broader array of different instructional scenarios, learning environments and educational institutions. To transfer a computer-supported collaboration script to another learning platform, usually a re-engineering is necessary, and the effort required for this purpose typically cannot be expended.

The same holds for the transfer of collaboration scripts of proven effectiveness into practice: If the scripts have been implemented as an integral part of a particular, often purely experimental, learning platform that is not open to and supported for the public, practitioners cannot simply use them and again, re-implementation on the platforms used in educational institutions typically is not feasible. To foster both

replications of script effects across domains and environments and the use of scripts of proven effectiveness in practice, ways to exchange scripts are necessary.

### Approaches to the Development and Implementation of Re-usable Scripts

To provide solutions for the replications of script effects across instructional scenarios, learning environments and educational institutions and the use of scripts of proven effectiveness in practice, several suggestions have been made. At least four aspects of sustainable script development can be distinguished (see Figure 1): (1) Frameworks enable script developers to specify their collaboration script using a collaboration-specific description language. Thereby, not only the description is standardized, but also dimensions for research are defined. (2) Authoring tools offer script designers more easily to create collaboration scripts. These tools usually provide a graphical interface. (3) An interface (including exchange formats/standards) is needed to run a script authored with an authoring tool in a specific (4) runtime environment. The runtime environment “plays” the scripts. It provides the human-computer-interface.

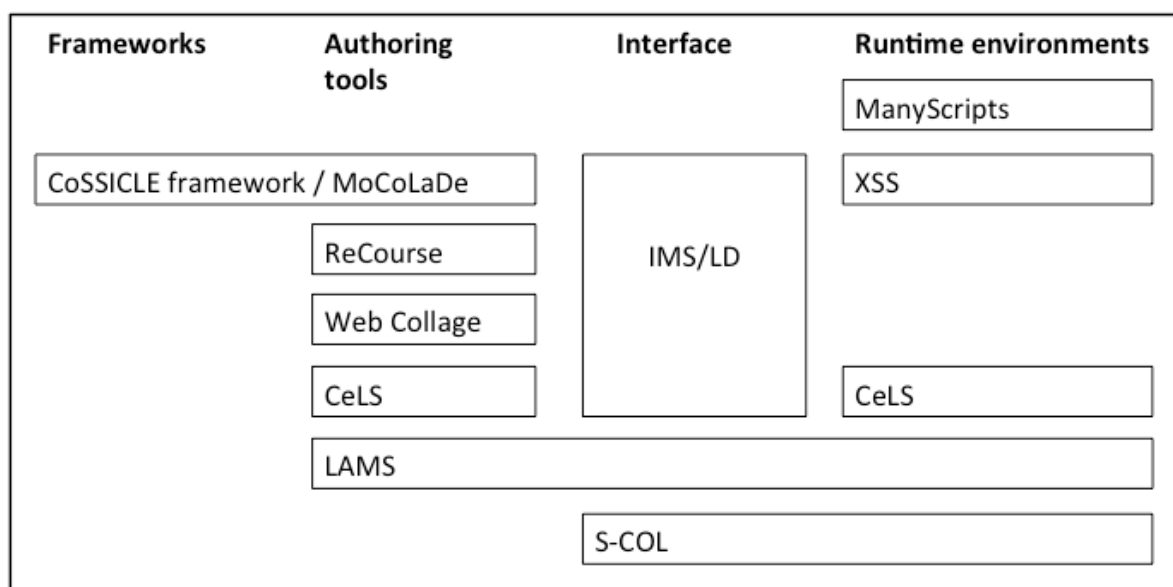


Figure 1. Aspects of the Sustainable Script Development and an Overview, Which Tool Focuses Which Aspects.

A prominent approach is the development of a common scripting language or a unified framework for the description of scripts such as the one developed by the European Research Team “CoSSICLE” consisting of educational scientists, psychologists and computer scientists (Weinberger et al., 2007): This framework (Kobbe et al., 2007) defines a small but still comprehensive number of components and mechanisms of computer-supported collaboration scripts. The components are participants, activities, roles, resources, and groups; the mechanisms comprise task distribution, group formation, and sequencing. The idea behind this approach is that each single collaboration script from a broad variety of script types can be described as a specific configuration of these components.

On the basis of this descriptive framework the graphical modelling tool MoCoLaDe for designing collaboration scripts has been developed (Harrer & Malzahn, 2006). This modelling tool produces an IMS/LD file as an output, i. e. a file that can be read by all learning platforms that support the IMS Global Learning Consortium Standards. An example of a runtime environment and functional framework that simplifies the implementation of scripts on devices such as tabletop displays or mobile phones by using a representation in IMS/LD such as the ones produced by MoCoLaDe is XSS (Stegmann, et al., 2009). The server component of the XSS framework is a runtime environment, while the functional framework offers a bundle of functions and classes to develop own GUIs for the clients. Other tool that create a computer readable script description in IMS/LD are Web Collage (Villasclaras-Fernández, 2010) or ReCourse (Griffiths et al., 2009). However, instead of an implementation on the basis of a script formalization, Web Collage offers specific script patterns (e.g. a jig saw pattern) and assessment capabilities to the user. ReCourse is quite similar to MoCoLaDe, but uses an adapted IMS-LD framework to describe collaboration scripts. Finally, CeLS has to be mentioned as tool that comprises capabilities for designing as well as enacting collaboration scripts on the basis of IMS/LD.

Graphical modelling tools do not necessarily produce a machine-readable output. LAMS (Ellaway, Dalziel, & Dalziel, 2008) allows to create learning designs with a pre-defined set of activities (incl. online discussions, questionnaires, etc.) that can be either “played” directly in LAMS or used for controlling other

learning platforms. The interface to other platforms is not implemented by means of an exchange format, but through a direct integration of LAMS and other learning platforms (e.g., moodle, Blackboard, Microsoft Sharepoint).

A different approach to the transfer of collaboration scripts to other settings has been offered in the “ManyScripts” project (Dillenbourg & Hong, 2008): Manyscripts offered teachers a web-based environment to adapt a set of specific scripts to satisfy their own needs, in particular their own learning material. “ManyScripts” did not offer the opportunity to develop new computer-supported collaboration scripts, but to change the learning material. Thereby, we regard “ManyScripts” not as a script authoring tool. Currently, the Concept Grid, Argue Graph (Dillenbourg & Jermann, 2007), and Ice (Dillenbourg & Hong, 2008) scripts are still available on the project website (Manyscripts, 2009). For example, the Argue Graph script composes groups with divergent opinions with respect to a specific domain (e.g., drug use in sports). To adapt the Argue Graph script, teachers can easily define their own questions that will be used to form these divergent groups. The ManyScripts environment is a standalone learning platform. A native integration into other learning platforms has not been a goal and is not supported.

In some sense, the S-COL approach follows an idea similar to the one behind ManyScripts, i. e. developing ready to use instances of collaboration scripts and making them available in other contexts. The difficulty in this approach is how to integrate these ready-made instances of collaboration scripts in the technological platforms used in other learning settings. S-COL solved this problem by means of a general interface to any kind of web pages (cf. Wecker et al., 2010). Thereby, collaboration scripts created once can easily be used on different learning platforms.

These different approaches all have their respective strengths and weaknesses. Often the current shortcomings of one approach match with particular strengths of another one, and there are chances for progress by combining them. Therefore, this symposium explores ways to advance development of methods for the seamless transfer of collaboration scripts to other platforms. It offers an overview of the most influential approaches and implemented tools to develop, investigate and transfer computer-supported collaboration scripts. On this basis, the future direction of the development and integration of a set of interconnected tools for script implementation and transfer will be discussed.

In the following, the individual approaches are presented in more detail. We clustered the approaches into authoring tools (MoCoLaDe, Web Collage) and runtime environments (CeLS, S-COL). We’re aware that CeLS and S-COL are hybrids (combining authoring tool or interface with runtime environment). However, their focus lies in both cases more on the runtime environment than on authoring or the interface.

## Authoring Tools

### MoCoLADe: Model for Collaborative Learning Activity Design

MocoLADe was developed as a graphical modelling approach based on the conjointly developed COSSICLE framework on collaboration scripts. Thus, it was built to allow the definition of collaboration scripts on a general level that is not tied explicitly to specific learning platforms and scripting engines. It provides an explicit mapping of COSSICLE’s components and mechanisms to respective graphical representations that allows visual specification of collaboration scripts without the need to be knowledgeable about specific educational modelling languages, as the XML binding of IMS/LD, or being restrained by specific tool(sets) within concrete learning environments, as in the case of the LAMS system (Dalziel, 2006). Among the features of the MoCoLADe language are different group formation strategies, role rotation, and distribution/collection of resources.

#### How Does MoCoLaDe Work?

MoCoLADe is an editor implemented as a Plugin to the collaborative whiteboard application FreeStyler. It is used as a stand-alone editor, i.e. independent of a specific learning system, with which the script designer creates graphical scripting models in formats that can be applied to different learning platforms. The main target platforms are IMS/LD compliant Learning Management Systems, but a proof-of-concept export to the learning platform CeLS and its proprietary format for learning processes was conducted as well.

#### How Does MoCoLaDe Advance Research on Computer-supported Collaboration Scripts?

MoCoLADe with its platform-independent modelling approach supports comparison of different scripting platforms as well as re-usability of script templates across different domains. In the first case, the same model / script could be exported to several platforms and practically tested with their specific functionality and realizations of learning activities. Thus it supports a comparative research on learning / scripting platforms. For the second case, a modelled MoCoLADe script can be re-used in different learning contexts and scenarios just by exchanging the material and resources provided to the students (e.g. a set of case descriptions from

Chemistry instead of Psychology). Thus, the transferrability of the same script in different domains can be explored and evaluated systematically.

### How Does MoCoLaDe Advance the Implementation of Scripts into Educational Practice?

MoCoLADe supports the implementation of scripts into practice in a twofold way. First, a designed script can be tested practically by the designer by means of interactive simulation. By stepping through a modelled script and checking the settings, such as current groups, role and resource assignments, a script can be checked for validity and potential pitfalls before putting it into practice. Second, the transformation mechanism of a script or a simulation run of a script to the de facto standard IMS/LD provides the seamless transition from convenient graphical modelling to enactment in IMS/LD supporting environments, without a designer having to be an expert in IMS/LD coding. Using application specific profiles (Harrer et al., 2009) the export of a model can also be tied to a specific learning platform and the tools available in that platform. Preliminary tests with an application profile for the CeLS learning platform have been performed and presented in (Harrer et al., 2009).

### **Web Collage**

*Web Collage* (Villasclaras-Fernández, 2010), an extension to the previous tool *Collage* (Hernández-Leo, et al., 2006a), was developed to aid non-expert designers, such as teachers interested in applying collaborative learning with computer support, in the creation of computer-interpretable collaboration scripts (Weinberger et al., 2009). Similar to MoCoLADe, by relying in the *de-facto* standard IMS/LD specification, *Web Collage* aims at creating interoperable scripts that can be enacted in any IMS/LD compliant player. More interestingly, *Web Collage* extends *Collage* in providing pedagogical support for configuring not only learning activities of the script, but also the related assessment support (Villasclaras-Fernández, et al., 2009a).

### How Does Web Collage Work?

*Web Collage* promotes a design process in which designers reuse design patterns in order to create the different components that compose a CSCL script. Currently, *Web Collage* lets the user apply two types of patterns: Collaborative Learning Flow Patterns (CLFPs), which codify well-known collaborative learning techniques (such as the *Jigsaw*, *Pyramid*, or *Think pair share*) (Hernández-Leo, et al., 2006b), and assessment patterns that correspond to common assessment techniques (Villasclaras-Fernández, et al., 2009b). The tool encourages the user to read the documentation of each pattern, in order to select the most adequate techniques for each case. Once a pattern has been selected, *Web Collage* automatically handles the creation of the components necessary to represent the chosen learning/assessment technique. In this way, non-expert designers can easily create scripts composed of complex collaborative learning structures. Moreover, *Web Collage* generates an interactive graphical representation of CSCL scripts depicting the learning and assessment techniques used, with the objective of facilitating the understanding of the expected collaborative learning processes (Villasclaras-Fernández, et al., 2009a). In addition, *Web Collage* implements an advisor system, which indicates potentially necessary actions to be carried out in order to complete the script, together with a brief explanation of the pedagogical rationale for each recommendation.

### How Does Web Collage Advance Research on Computer-supported Collaboration Scripts?

The generation of a CSCL script is a complex task, and many aspects need to be taken into account in the design task. *Web Collage* recognizes the relevance of assessment embedded in collaboration scripts and encourages a design process in which alignment between learning and assessment is a key design goal (Villasclaras-Fernández, et al., 2009a). On the other hand, more aspects of the design process need to be tackled as well, such as aid for the configuration of the distribution of documents among participants in a script, the integration of flexibility, support to create or reuse learning/assessment existing resources, etc. These new elements may be eventually included in a complete design process (Villasclaras-Fernández, et al., 2009c). With respect to this, the development and evaluation of both *Collage* (Hernandez-Leo et al., 2010) and *Web Collage* (Villasclaras-Fernández, 2010) represent relevant milestones towards this objective. On the other hand, the ability to easily produce scripts suitable for specific learning situations facilitates the involvement of teachers in research case studies in which technologies, such as Virtual Learning Environments, are tested in authentic scenarios. In this way, *Web Collage* may be (and has been) used as a resource in TEL research.

### How Does Web Collage Advance the Implementation of Scripts into Educational Practice?

The objective behind the development of *Web Collage* is to enable any type of designer to create pedagogical sound computer-interpretable CSCL scripts. Considering that the access to the technological resources necessary to enact CSCL scripts is becoming wider and wider, the possibility of easily creating CSCL scripts is very attractive in the case of teachers without extensive experience of CL or technology. Coupled with IMS/LD players, any teacher could potentially create a CSCL script for their specific needs (Villasclaras-Fernández, et

al., 2009c). The usage of design patterns and the graphical representation, on the other hand, are expected to increase reusability of CSCL scripts by facilitating the understanding of scripts created by others.

## Runtime Environments

### CeLS: Collaborative e-learning Structures

CeLS is a web-based environment aimed to provide a flexible tool for designing, creating, enacting, sharing and reusing online collaboration scripts and incorporating them in existing instructional settings. CeLS special feature is the controllable data flow: the ability to selectively reuse learners' artifacts from previous stages according to various Social Settings and to support the design and enactment of rich multi-stage pedagogical scenarios (Ronen et al., 2006; Ronen & Kohen-Vacs, 2010).

#### How Does CeLS Work?

A script designed in CeLS may include any number of stages. A stage comprises a combination of basic building blocks, while each building block generates a certain type of interface in the student's environment. The special feature in the CeLS approach 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. In the CeLS approach the social aspects are the key for controlling the data flow within a script. Each building block can be assigned particular Social Settings that determine what information would 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. This approach allows for the design and implementation of adaptation patterns (Ronen & Kohen, 2009). During enactment with students the teacher has full control and can introduce necessary 'on the fly' changes of the script. CeLS is an independent environment though it could be interfaced with other systems that support aspects of scripting, such as MoCoLaDe to expand the potential offered for modeling and enacting pedagogical scenarios (Harrer et al., 2009).

#### How Does CeLS Advance Research on Computer-supported Collaboration Scripts?

CeLS flexible architecture supports the design and enactment of a large variety of scripts, thus offering a tool for conducting empirical research on the pedagogical efficacy of different types and versions of activities (Kali & Ronen, 2008; Hammer et al., 2010) and for exploring how teachers adopt the use of scripts in real settings (Ronen & Kohen-Vacs, 2010).

#### How Does CeLS Advance the Implementation of Scripts into Educational Practice?

CeLS is designed to encourage and support teachers to incorporate online collaborative activities into their daily practice by providing them with a flexible tool and examples that they can explore, adopt and adapt. Teachers can also express their pedagogical creativity and design new scripts from basic building blocks. CeLS is used by teachers at all levels (elementary school to higher education) in variety of subject domains: education, psychology, science, technology, medical professions and arts (Abrahamov & Ronen, 2008; Kali & Ronen, 2008). The early adopters are teachers, at all levels and subjects, who are already trying to use the available technology for conducting collaborative activities in their courses. CeLS has enabled them to design and implement pedagogical activities that were very difficult or impossible to handle before.

### S-COL: Scripting for Collaborative Online Learning

S-COL was developed to solve the problem of how to use collaboration scripts in combination with multiple learning platforms. The suggested solution implements collaboration scripts and scaffolds as part of a web-browser and thereby allows for the sustainable development of scripts and scaffolds that can be used with a broad variety of content and platforms.

#### How Does S-COL Work?

The S-COL (Scripting for Collaborative Online Learning; see Wecker et al., 2010) approach to support research on collaboration scripts and their transfer into practice is to implement support measures as part of the browser and trigger them based on the recognition of types of functionally equivalent pages on the Internet. With respect to online discussions, for example, these important types of pages are the form for composing a new message and the list of all posted messages. If the browser plug-in recognizes a specific type of page, it triggers specific kinds of support embedded in the browser. Furthermore, S-COL establishes a communication channel between all connected Web browsers to allow synchronization of activities within groups (e.g., synchronized switching of roles etc.). Administrative functions allow teachers to manage groups and select adequate support measures



from a scaffold library. For the developers of new collaboration scripts, S-COL offers a library with functions that allow fast implementations of new kinds of support. The features of S-COL that allow for an easy implementation of scripts allow also several additional functions such as logging the navigation behaviour or the transfer of identification data from pre-test to post-test in field studies.

### How Does S-COL Advance Research on Computer-supported Collaboration Scripts?

Computer-supported collaboration scripts developed by different researchers differ regarding more aspects than just the specific process that they aim to facilitate. The collaboration scripts are often an integral part of the experimental learning environments (e.g., Stegmann et al., 2007). Replications of effects of specific scripts using other learning platforms than the origin are usually not done. Using S-COL may help to tear down these invisible walls between research labs. The effects of the very same script can be examined using different learning platforms and also across different cultures. This is the only way to investigate interaction effects between the script, the learning platform at hand, and the cultural background of the learners.

### How Does S-COL Advance the Implementation of Scripts into Educational Practice?

Once a script is developed and successfully evaluated, S-COL allows for easy distribution of the script. Regardless of the learning platform in use, the script can be used to support collaborative learning. Because the scripts are implemented as a ready-made part of the browser, their adaptation to any collaborative learning platform requires nothing more than the adaptation of the template file for the recognition of the page types within the learning platform actually used. For example, by inserting unique features of the message composition form of the online learning environment (e. g., URL, control elements such as text boxes or buttons) into the template file, S-COL is enabled to recognize the types of functionally equivalent pages.

## **Discussion**

And the winner is? Of course, it would be more dramatic to elect one approach as the best. The truth is that all approaches have their strengths and weaknesses. None fits all needs of research *and* transfer in to practice sufficiently. One conclusion could be to have different tools for different purposes. However, the main problem seems to be the gap between research and transfer into practice. Most tools presented are either focusing on one or the other aspect. To close the gap, an approach is needed that integrates different approaches. A combination of concrete learning environments that support scripting (e.g., CeLS) including script libraries (e.g., ManyScripts), languages, frameworks and according editors to develop new scripts and describe them in a machine-readable format (e.g., MoCoLaDe, Collage), and tools that allow the transfer of scripts between different learning platforms (e.g., S-COL).

The conclusion should rather be that we need the “CeLS-ManyScripts-MoCoLaDe-Collage-S-COL” approach. To support research and transfer into practice at the same time it would be preferable to have a tool that allows an easy development of scripts and the transfer of scripts between learning platforms. The platform needs to understand patterns and/or IMS/LD and should offer a script library with effective scripts that can be easily adapted and further developed by educators. Furthermore, learning platforms are needed that offer an interface to realize specific aspects of collaboration scripts, like group formation on the base of meta-data of users.

## **Symposium Activities**

The goal of the symposium is to bring together educational researchers, computer scientists and practioners to discuss an agenda for the next steps to facilitate the sustainable development of collaboration scripts. Therefore, we start the symposium with an overview of four exemplarily tools. Each approach will be shortly introduced in a firehose presentation with examples of current research and a short demonstration. Then, strengths, limitations and future directions for each tool will be discussed . Next, a discussant will provide anchors for the discussion with the audience about the pros and cons regarding research on and transfer of the different approaches. The discussant will be Armin Weinberger, who was the leader of the European Research Team CoSSICLE (Computer Supported Scripting of Interaction in Collaborative Learning Environments). This research team developed the aforementioned specification of computer-supported collaboration scripts (cf. Kobbe et al., 2007) that strongly influenced all the approaches presented in the symposium. The final phase is reserved for an open discussion and idea generation about the agenda to integrate the approaches.

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## Part 3



# Interactive events, demonstrations & CSCL in practice showcases

## Enhancing the Social and Cognitive Benefits of Digital Tools and Media

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**Abstract:** While new media have greatly magnified people's opportunities for access to and sharing of knowledge and ideas and for forming social networks they have not performed so well as media for the collaborative production of new knowledge. In this symposium, researchers with experience in efforts to advance knowledge building apply insights they have gained to the question of how to enhance the socio-cognitive benefits of new media. We suggest development of a technological, social, cognitive and epistemic infrastructure for creative knowledge work. Toward this end we propose engaging teachers in design research along with researchers and subject-matter experts, enhancing students' ways of contributing to the pursuit of causal explanations, and introducing technological advances that provide greater support for high-level knowledge processes. We argue that teachers and students must be major players in the design and working of an infrastructure for creative knowledge work.

### Focus of the Symposium

New digital tools and media are having a transformative effect on the way people form relationships, process information, reach decisions, and share and generate knowledge and ideas. Nevertheless, shortcomings have become evident. The most conspicuous, from a socio-cognitive standpoint, is the absence of the kind of sustained collaborative discourse that solves problems and builds new understandings. Tweets are not a way to advance what Homer-Dixon (2000) has called "ingenuity"—the supply of explicit know-how available for use in problem solving. The wildly popular social sites, such as Facebook, connect people but they cannot really be said to connect ideas, much less to support sustained elaboration and improvement of ideas. Open Educational Resources and *Wikipedia* provide individuals with extraordinary access to existing knowledge, but the potential of collaboration to help internalize, apply, and extend this knowledge gets little technological support. It is easy to attach a discussion board to any online document, but the resulting discussions tend to be too localized to produce sustained idea development. We occasionally see sustained idea development in blogs, but this is usually because the blogger has chosen to use the medium as a thinker's notebook. Typically such blog entries are monologues, sometimes with comments from others, sometimes not.

The preceding criticisms are personal impressions. Except for discussion threads, which have been around long enough to become objects of socio-cognitive research (e.g., Hewitt, Brett & Peters, 2007; Hewitt & Brett, 2007), there is little firm evidence to support them. However, the focus of this symposium is not on criticism but on constructive dialogue. Assuming that there is always room for improvement, this symposium will focus on ways to enhance social and cognitive benefits, both through the design of technology and through improvements in the way it is used in education. In approaching the problem of enhancing socio-cognitive benefits of new media, this symposium will focus on what appears to be a crucial missing element: support for

sustained, collaborative, problem-solving dialogue centered on ideas rather than on the documents or other media artifacts that embody them. The symposium brings together researchers and innovators who have different perspectives on how to bring more collaborative learning and knowledge advancement into the use of new social and knowledge media. Viilo, Seitamaa-Hakkarainen, and Hakkarainen discuss the kinds of learning experience students need in order to get to the point where they can sustain knowledge-building dialogue independently. J. Oshima, Yamaguchi, Nakayama, Inagaki, R. Oshima, Sakamoto, and Yamamoto consider the crucial role of the teacher's epistemology in determining how digital tools and media will be used in classroom learning and knowledge building. Bereiter, Chen, Chuy, Resendes, and Scardamalia discuss classroom interventions and software tools aimed at engaging students in identifying and elaborating the kinds of "big ideas" increasingly called for in educational standards.

## Organization of the Symposium

Panelists will discuss theoretical underpinnings of their recommended means for enhancing the socio-cognitive benefits of digital tools and media. They will identify top-level concerns and proposed solutions for remedying the situation, with the audience engaged in discussion and analysis of both the conceptual framework and proposed solution. The discussant is deeply involved in research in this area and will engage the audience in this highly interactive session.

## Contributors and Presentations

### The Teacher's Role in Developing the Socio-cognitive Infrastructure for Progressive Collaborative Inquiry (Viilo, Seitamaa-Hakkarainen, & Hakkarainen)

Few would question that realizing the cognitive benefits of new knowledge media depends on having them incorporated into effective knowledge practices. What is less well recognized, however, is that acquiring these knowledge practices represents for students a higher-order educational achievement in its own right, and it may require long-term guidance by skilled teachers using pedagogy appropriate to the task. Many knowledge building studies unintentionally give the impression that students could engage in collaborative knowledge advancement on their own. They report students' great achievements and leave aside the teacher's guiding role or the value of suitable classroom practices (Hakkarainen, 2009). When teachers try to implement knowledge building in their classrooms, they may become discouraged when students initially fail to pose meaningful questions, generate relevant intuitive theories, or engage in productive discourse interaction. Many intended knowledge building experiments neither facilitate genuine inquiry nor demonstrate knowledge advancement. Advancement of local knowledge-building communities occurs when the teacher iteratively works to transform local classroom practices toward inquiry-based ones, involving students' participation in collaborative knowledge building. There are clear needs for research on productive pedagogical practices concerning collaborative inquiry.

In addition to a *technological infrastructure* and a suitable *social infrastructure*, progressive collaborative inquiry requires an *epistemic infrastructure*, within which knowledge is treated as something that can be shared and jointly developed by participants, and a *cognitive infrastructure* of knowledge practices—ways of working with knowledge and ideas and their embodiments in various media objects. Hakkarainen and colleagues have developed a pedagogical model of progressive-inquiry (PI) learning model (Hakkarainen, 2003; 2004), inspired by Scardamalia and Bereiter's (2006) knowledge-building framework. The PI model is a tool that assists teachers in engaging their students in expert-like creative knowledge practices. The idea is that the teachers should guide students themselves to assume responsibility for all aspects of inquiry, such as goal-setting, questioning, explaining, and evaluating; they must guide students' process of inquiry by their own example. The model consists of several elements that constitute essential aspects of a cyclic process of solving problems and advancing local, collective knowledge. *Shared expertise* means that the participants of knowledge creating inquiry are not isolated individuals but a classroom learning community that pursues joint investigation by sharing all elements of progressive inquiry. *Construction of working theories* guides the participants to stretch their knowledge and understanding for creating shared epistemic artifacts for supporting subsequent inquiry efforts. By *critically evaluating* their advancement, individuals, teams, and the whole inquiry community are able to focus their subsequent inquiry efforts toward promising directions. The question-driven process of inquiry provides heuristic guidance in the *search for new information* for directions and sources not determined by the teachers or initially anticipated by the participants. The process of inquiry starts with initially very general, unspecified and "fuzzy" questions and tentative working theories; advancement of inquiry entails that the participants focus on improving their ideas by *generating more specific questions* and searching for new information for directing further investigations (Hakkarainen & Sintonen, 2002).

In this presentation we trace the work of one teacher in implementing this model so as to establish among the students the knowledge practices constituting a *social, epistemological, and cognitive infrastructure* for progressive collaborative inquiry. The teacher assumed the role of organizer concerning collaborative

progressive inquiry and designing activities. This was based on continuous following of the pupils' current state of inquiry process. The teacher diary revealed the epistemic infrastructure when she is concerned with how to guide and support students' deepening inquiry and how to encourage them to propose *why* questions without guiding them too much. In the social infrastructure she considered the students' teams' activities and their interaction. During the project she reflected on individual student's roles, highlighted their special areas of expertise, and supported creation of collaborative culture. In terms of developing methods of creating and sharing views and making collective discussion notes during the process, she constructed a technological infrastructure based on inquiry use of Knowledge Forum. Knowledge Forum structured the process and mediated activities, and rendered knowledge objects visible and accessible to the whole learning collective. Successful knowledge-building cultures are usually based on single classes in which there is an exceptionally motivated and committed teacher (Hakkarainen, 2009); this was, indeed, the case in the present study. We suggest that in order to expand and scale-up advanced inquiry practices, the teacher's usually invisible work in guiding and directing classroom practices has to be made visible and analyzed in detail.

### **Teacher Epistemology and Constructive Uses of New Media (J. Oshima, Yamaguchi, Nakayama, Inagaki, R. Oshima, Sakamoto, and Yamamoto)**

Teacher development is imperative if the potential socio-cognitive benefits of new media are to be realized in classrooms. However, it would be a mistake to limit teacher development to uses of the new media. How technology is used in classrooms will be to a large extent determined by how teachers integrate it into subject-matter instruction, and this in turn will be much influenced by the teachers' knowledge of the discipline and their epistemology as it relates both to disciplinary practice and to learning (Duschl & Wright, 1989; Lederman, 1992; Tobin & McRobbie, 1997). In their investigation of high school teachers' planning and teaching science, Duschl and Wright (1989) found that the teachers made their decision in the selection, implementation, and development of instructional tasks significantly based on student development, curriculum guide objectives, and pressures of accountability. The teachers were found to give no consideration to the nature or role of scientific theories or structure of the subject matter. They concluded that such significant deficiency in teachers' decision-making in the science classroom can be explained by their lack of knowledge about the nature of science. A case study of one science teacher by Tobin and McRobbie (1997) found that the students' and teacher's goals for the course were perfectly congruent with each other, although at variance with those of the intended curriculum, and that as a result significant change in instruction was resisted by students as well as the teacher. In our work, we have applied design-based research to teachers' professional development, focusing specifically on their epistemological perspective on learning. We collaboratively participated in design-based research practice with several Japanese teachers for more than 10 years. Here, we describe the first three years of our experiences with one teacher, Teacher Y, who showed a critical shift in his epistemological perspective on learning. Our design-based research team consisted of several school teachers, learning scientists, science education researchers, and domain experts from four different institutions. As a team we designed two lesson units a year for an elementary school science curriculum. In his first design-based research, Teacher Y participated in the practice by primarily watching design meetings, colleagues' practices while taking field notes, and attending post-practice meetings. In addition to taking the observer role, Teacher Y was required to report what happened during students' activities in each class and what he thought about the practice. Analysis of video records of the design meetings and interviews revealed that Teacher Y interpreted the classroom practice based on his pre-existing epistemological perspective of learning; he was not concerned with issues that researchers focused on.

In the course of designing subsequent science units, however, Teacher Y came increasingly to adopt a new epistemological stance, which carried over into his classroom practice and his use of technology. During his teaching, Teacher Y monitored students' activities in the classroom intensively, and worked on supporting them by engaging in knowledge building discourse. In his report on a class, he described his reflection on how to use Knowledge Forum® as follows:

When I built on notes by students, *I kept in mind that I should regularly suggest conceptual links between notes*. For instance, I wrote "Your notes may be related to the notes of Group 5, so I think you may find interesting ideas from their notes." I also encouraged students when they revised their notes based on others' comments. When they forgot to revise their ideas even if they had comments from other classmates, I reminded them to revise their notes. I hope that *my scaffolding would facilitate knowledge building discourse online*.

From his report on how to support students' knowledge building discourse, we found that his suggestions given to students were based on principles of knowledge building such as *symmetric knowledge advancement in knowledge building* ("I kept in mind that I should regularly suggest conceptual links between notes"), and *improvable idea* ("I hope that my scaffolding will facilitate knowledge building discourse online"). In our interview with him, Teacher Y further suggested that he was intentionally attempting to apply his new

epistemological understanding to his teaching practice in the classroom. He recognized that he could integrate the new epistemology acquired through his participation in the design-based research practice with his pedagogical content knowledge.

For two years, I have been working with learning scientists like Professor O. The opportunity to participate in this research project was really helpful for me to *link the new theoretical perspective on learning to what I would always like to do in the classroom such as facilitating student understanding through collaborative learning*. Now, I have a theoretical background on knowledge building behind what I am doing in the classroom. This is very powerful.

What proved to be quite profound changes in Teacher Y's epistemology and teaching practice did not come about through professional development focused on teacher beliefs and understandings but rather through participation in research-based design in collaboration with people who operated according to a more constructivist epistemology. This suggests that "learning by doing" and knowledge building principles such as *epistemic agency* and *knowledge building discourse* can apply as much to professional development as they do to classroom learning.

### **Causal Explanation: A Way to Achieve Greater Cognitive Benefits from Knowledge Media (Resendes, Chuy, Chen, Bereiter, & Scardamalia)**

Causal explanation is an essential part of disciplinary understanding. This means that a large part of school subject-matter only becomes useful to the extent that students understand how facts are connected causally. Inquiry approaches in education put heavy emphasis on students' own pursuit of understanding, and in this context it means students trying, usually in collaboration with other students, to produce coherent and factually valid explanations. The research to be reported in this session explores ways to raise the level of students' explanations and the explanatory coherence that they are able to bring to their collective work. Assuming that most explaining is done interactively—that is, through dialogue—the research focuses on kinds of contributions students can make that move explanation-building dialogue forward. It starts with work in the field of science and then extends to work in history, with results informing designs of new knowledge media to increase students' repertoires for knowledge-advancing conversations

Explanatory coherence, as defined and computationally modeled by Thagard (1989, 2006), involves both coherence among explanatory propositions and coherence with acknowledged facts. Also known as reasoning to the best explanation, it has mostly been studied in relation to scientific theories, but McCullagh (1984) has given it a central place in historical reasoning as well. Explanatory coherence can include both "hot" and "cool" cognition (Thagard, 2006) and can deal with causation in terms of human motives and actions as well as impersonal forces (Read & Marcus-Newhall, 1993; Thagard & Kunda, 1998). Explanations can take narrative as well as paradigmatic (*e.g.*, argument) forms (Bruner, 1986). The "qualitative models" that precede formalization in science often take narrative form (Bobrow, 1985), and for young students scientific explanation often goes no farther than construction of a coherent narrative, and thus is not fundamentally different from explanatory narrative in history. Accordingly, explanatory coherence provides a common framework for evaluating dialogue in science and history education and a common goal for efforts to raise the level of student discourse in these subjects.

Enhancing students' ways of contributing to the pursuit of explanatory coherence goes to the heart of creative disciplinary thinking in both science and history. Research that is in an early stage in our research team is seeking to catalogue distinctive ways that individual students can contribute to explanation-seeking discourse. Examples of types of contributions that have a generally positive effect in moving a discussion toward coherent causal explanations are distinguished from ones that have little or negative effect. This work is setting the stage for the next stage of research in which feedback will be provided to students regarding ways of contributing toward more positive effect. In this phase we experiment with more targeted interventions designed to boost the level and quality of students' contributions to explanation-seeking discussions. Planned interventions include use of analytic assessment tools which students can call up on their own, "seeding" discussions with types of contributions the students are neglecting, and enlisting the students in developing the catalog of contribution types and the visualizations being developed to illustrate them. Through this research we hope to provide ways of achieving deeper mastery of core school subjects and boosting the quality of student discourse. The research should furthermore help in equipping students with communication and collaboration skills that will serve them in other contexts, in later education, and in knowledge work. Another outcome of the project will be a set of tools and practices that will enable others to extend this work.



## **Generic Improvements in Communication Technology to Enhance Socio-cognitive Gains (Chuy, Chen, Resendes, van Aalst, Chan, Scardamalia, & Bereiter)**

Drawing on wide-ranging research on technologically supported knowledge building (most recently consolidated in a special issue of the *Canadian Journal of Learning and Technology*), we here discuss generic improvements in technology that could enhance socio-cognitive benefits. By “generic” we mean improvements that are not tied to any particular technology and that are potentially applicable in a variety of media environments—ranging from learning management systems to social networking sites and from wikis to video sharing sites. A companion presentation in this symposium will deal with achieving these improvements in Knowledge Forum, a software environment specifically designed to support creative knowledge processes (see Scardamalia, 2004, for detailed description).

The ideal is that any media object should be treatable as an object of inquiry and knowledge building. To a very limited extent this is done now by attaching discussion boards to such diverse objects as blog posts, news articles, and online videos. Often these become platforms for venting opinions; at best they are platforms for sharing knowledge and giving advice. Rarely, if at all, are they platforms for sustained knowledge-building discourse. It is not that such discourse is impossible, only that the technology provides no support for it. Most online communication tools adopt a conversation-oriented interaction with participants’ ideas distributed across messages and responses addressing individual and oftentimes the most recent entries. It then becomes difficult for them to see the whole picture of the extended discourse and understand and review group-level progress in the community’s knowledge (Hewitt, 2001; 2003). As a result, their discourse contributions are often disconnected and redundant, covering the same ground without significant progress. Generic improvements would include the following:

- Easy ways to reference other participants’ ideas. With traditional threaded discourse technology, this can only be done by attaching a comment to a specific post. (Often even this facility is lacking, so that a respondent has to copy and paste part of the message being referred to. Continued discussion means further copying and pasting, to the point where the exchange becomes virtually unreadable.) Integrative knowledge building requires being able to reference several items, including different people’s contributions as well as outside information sources, and to build on those.
- Ability to draw ideas together into a higher level of idea organization.
- Ability to use different media in representing ideas without segregating them into different applications; e.g., being able to incorporate a simulation into a verbal explanation.
- Rich and abundant feedback and visualization mechanisms that enable a variety of “metacognitive views” (Brown & Campione, 1996) on an unfolding discourse.

Open Education Resources (OER) (Atkins, 2007) provide a context in which sustained knowledge-building discourse would be highly desirable. Individuals now have access to educational opportunities formerly available only to students in top-flight universities. But, unless they are enrolled in some organized program, they do not have the benefit of the social supports, the knowledge sharing, and collaborative building of understanding that can be gained in a quality campus milieu. We are undertaking with collaborators at Carnegie-Mellon University experiments in merging a knowledge-building environment into their Open Learning Initiative (OLI). OLI provides not only access to quality content but also access to instructional software to support learning and exploration of that content (Thille, 2008; Lovett, 2008). Our goal is to work with their courseware designers to provide technology that encourages collaboration at a distance in achieving deeper understanding.

A case study in the OLI context will be completed in the spring of 2011. Its focus is one teacher’s effort to integrate individual learning with collaborative knowledge building, and the main question is whether this effort can enhance both individual learning and group cognition (Stahl, 2006). The research includes interviews with the teacher regarding the effect on their practice from combining these environments, facilitated by being able to toggle between the individual learning and collaborative discourse environment. Analytic tools embedded in both the individual learning and collaborative discourse environments will provide a detailed picture of the student experience and help us articulate how students benefit from the different components and instructional devices. Based on results of the case study, we will consider issues such as the following: If learning is enhanced for a few students, do their contributions to the collaborative space enhance the work of the group? How can we assess growth and spread of ideas? Can we keep ideas alive and improving in a worldwide open community?

## **Advancing the Design of Knowledge-building Software (Chen, Resendes, Chuy, Bielaczyc, Hong, Scardamalia, & Bereiter)**

Knowledge Forum is a software environment that enables coordinated use of a number of affordances for knowledge advancement, such as graphical views for meaningful note organization, facilities for citing others’ work, and “rise-above” notes for producing higher-level syntheses of ideas. Four advances in Knowledge Forum

design are currently under way, all aimed at further empowering users to work creatively with knowledge and ideas. These are (a) supports for capturing the key ideas in notes and flexibly characterizing them; (b) scaffolds to raise the discourse to increasingly high levels, (c) visualizations to focus attention on a subset of notes with a specific goal for advancing collective work, and (d) concurrent evaluation that can become part of an ongoing knowledge-building process. Through such means we aim to show that students can take over levels of work normally reserved for the teacher and not supported by conventional courseware.

**Tagging key ideas.** Multifaceted “idea tagging” helps authors identify the essence of a note and reflect on it more deeply. In turn, tags provide a more comprehensive system of note links to extend possibilities for new view creation and higher-level knowledge work. As a simple example, a keyword “wand” allows a user to highlight a word in a note. Keywords then serve as search parameters so notes sharing designated keywords can be viewed as a cluster. Similarly larger segments of text can be highlighted as “big” or “promising” ideas (labels are customizable) and searches allow these ideas to be retrieved for further development, with ideas prioritized based on number of “hits”.

**Scaffolds.** Scaffolds that label and provide sentence-starters for various “thinking types” have been a popular and frequently imitated feature of Knowledge Forum from its earliest origins in CSILE (Scardamalia, et al., 1989). Because scaffolds are customizable they can support whatever form of discourse the community is particularly interested in—diagnoses, causes, theories, analogies, and so forth. As Chuy et al., (in press) demonstrate, scaffolds can raise the level of discourse beyond developmental expectations. And since scaffolds can facilitate after-the-fact analysis of ideas, as well as provide support for the generation of new ideas, they can be designed to support analysis of student notes *by students*. Up to this time, a simple set of theory-building scaffolds has carried the main burden of partially structuring knowledge-building discourse (“My theory...,” “I need to understand...,” “A better theory...,” etc.). The current effort is to provide more complex scaffolding based on a model of “good moves” in problem-solving dialogue. For example, one set of scaffolds will promote a metacognitive view of the dialogue’s progress. Students might use the following scaffolds to analyze their progress: “An idea that represents our point of greatest progress,” “A misconception hampering progress...,” “We haven’t followed through with....” Note the emphasis on how “we” are doing, in contrast to the more individualistic emphasis of the original scaffolds.

**Visualization.** Information visualization is a powerful tool for searching, filtering, and transforming large amounts of data into a form that facilitates human interaction with it. Visualization tools being incorporated into Knowledge Forum help users explore and understand database content and facilitate the use of the idea tags mentioned above. The tools also provide visualizations of social and semantic relational structures. The design challenge in using these visualizations for knowledge building is to support real-time interaction and modification of information represented in the visualization. In our experience the form of visualization users have found most helpful is one that filters out all notes other than those that meet a small number of criteria so that the visualization dramatically lowers the amount of information to be processed. For example, users might wish to bring all notes with the scaffold support “An idea that represents our point of greatest progress,” forward, so what they see and work with on the screen is the small subset of notes tagged with that particular scaffold support.

**Concurrent, embedded, and transformative assessment.** Concurrent assessment means that the assessment is available instantaneously. Embedded means that it is integral to the workings of the organization rather than being functionally distinct. Transformative means that the evaluation is not simply an account of past performance and next immediate steps, but also provides indication of ways individuals and teams can tackle broader problems and situate their work in relation to that of other team members, including teams outside the school walls. An example of the kind of concurrent, embedded, and transformative assessment we are working on is automated detection of misconceptions. Use of Knowledge Forum in a health sciences short-course on pain management revealed the importance of being able to monitor the incidence and possible spread of misconceptions. This was done by hand coding—a slow and labor-intensive process. Automated detection, even if less accurate, would yield important benefits in alerting students and instructors to possible trouble spots. To achieve such automated detection, high-powered prior semantic analysis will contrast documents exhibiting recognized misconceptions in a domain with documents representing accepted knowledge, yielding a set of markers that distinguish the misconception laden-texts. These markers (typically specific words) may then be used in a simpler and less computationally intensive concurrent analysis to identify likely misconceptions. The possibilities for data generated automatically from student discourse and artifacts seem to have no bounds and allow a community to engage in its own internal assessment, which is both more fine-tuned and rigorous than external assessment. This then serves to ensure that the community’s work will exceed the expectations set by external assessors.

**Jianwei Zhang**, as Discussant, will review and reflect on the socio-cultural and cognitive dynamics of knowledge creation addressed in the presentation, highlight challenges faced by teachers and students, and identify areas of technological enhancement and pedagogical research to better support idea-centered, sustained problem-solving dialogue.

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## Common Boundary between Different Worlds: Collaboration between Researchers and School Teachers in NLC KB Project in Singapore

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**Abstract:** This interactive session showcases three models of nature learning camp-knowledge building (NLC-KB) program in Singapore - knowledge. They are the result of productive work of different stakeholders in this design research around boundary objects – knowledge building and environmental science. The goal of this session is thus to present boundary object as a methodological concept to understand how the different stakeholders work together to create a different KB-NLC program for their school, yet with resemblance of the KB-NLC community. The interactive session will include presentations of the three models by three different schools.

### Description of Project

The aim of this design research project is to develop a collaborative elementary science program that fosters deep understanding of the nature of science (NOS) and environmental science knowledge through a knowledge building approach. The NOS covers the epistemology of science, science as a way of knowing and the values and beliefs inherent in scientific knowledge (Lederman, 2007) whereas environmental science fosters opportunities to acquire knowledge, values, attitudes, commitment and skills to protect and improve the natural environment (Hart, 2007). Both NOS and environmental science have inherently attitudinal and affective components that are reportedly best developed through the inquiry approach. The latter is modeled after the scientific process of theory building (Schwarz, Lederman & Crawford, 2004) which has many parallels with knowledge building principles in the learning sciences.

This research dovetails onto an existing annual nature learning program for primary school students, called the Nature Learning Camp (NLC). Started some 10 years ago by a group of environment enthusiasts comprising an environment researcher, a group of primary school teachers from different local schools in Singapore and personnel from National Parks Board, the one-day event incorporated short-science inquiry activities to help primary school students learn about the local ecosystems, in particular the freshwater and rainforest reserves in Singapore. However, due to the brevity of time spent on the activities, these science activities might not make much lasting impact to the students, which really requires sustained tapping into attitudes and affect. The intention of this design research is therefore to extend the original one-day NLC program into a year-long program to engage students in collaborative theory building activities. The goal is to expand students' understanding and appreciation of the natural world and to enrich what they would learn in school. Knowledge Building (Scardamalia & Bereiter, 2003) approach is adopted to encourage students across schools to work more extensively with scientific data collected and to advance the collective knowledge of the NLC community. To mediate the knowledge building process among students, Knowledge Forum, a computer-supported collaborative learning system is used. With an emphasis on environmental science and NOS in the local primary science curriculum, this study aims to generate insights and exemplars for science educators on boundary crossings between formal learning in the classroom and out-of-school contexts. In short, the study aims to achieve the following objectives:

- a. To create and refine a collaborative knowledge building learning model mediated by Knowledge Forum (KF), a computer-supported collaborative learning (CSCL) system, for primary science classrooms in Singapore;
- b. To deepen students' understanding of NOS, particularly the role of theories in experimentation and scientific knowledge creation during inquiry activities; and

- c. To advance students' knowledge and affect towards environmental science.

This study involves three main groups of stakeholders – primary school science teachers, environment enthusiasts including the environment researcher and a few primary science teachers, and principal investigators of this project. A total of four primary schools participated in this study. As a multi-disciplinary team, the study is an integration of different interest/research areas of science education and learning sciences – knowledge building, environmental issues and school science. With each stakeholder working towards different goals in the program, the concept of boundary object is used to understand how different stakeholders work to develop a KB-NLC program in their own school while maintaining a common object that binds the members of intersecting social worlds together in this research project. In achieving the goal of the research study, each school has developed their own KB-NLC program, each with different learning outcomes yet recognizable in the motive that drives the activity.

### Theme of the Interactive Session

The session showcases three examples of KB-NLC programs implemented in different schools that exemplify the productive work of different stakeholders in this design research around boundary objects (Star & Griesemer, 1989). Boundary objects, according to them, are the intersecting objects of different social worlds/communities which are “plastic” to meet the needs of different communities yet “robust” at the same time to be “recognizable” across different worlds (p. 393). Using the concept of *boundary object* (Star & Griesemer, 1989), we examine how different stakeholders and the principal investigators work together around their differences to implement Knowledge Building in their NLC activities while keeping to the fidelity of a common object that bound the community. Figure 1 shows the intersecting worlds of the three groups of stakeholders in this design research to create a boundary recognizable by its common motive, processes and environmental themes that KB activities are based on. All three case examples in this presentation emphasized on revision and refinement of students' scientific ideas through iterative cycles of show-and-tell, collaborative (online discussion) and experimentation. All these KB activities were conducted around themes related to environmental science.

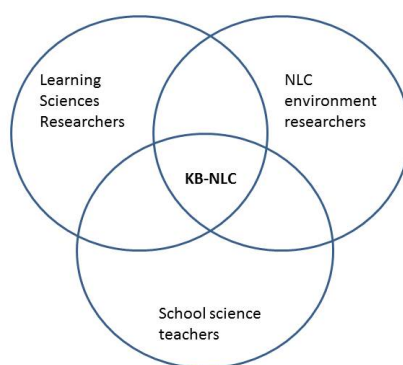


Figure 1. Intersecting Social Worlds.

While the plasticity of the boundary objects characterizes each case example as part of the KB-NLC community, the flexibility of boundary objects distinguishes each one as they differ in terms of their learning outcome, space and time. One KB-NLC case example was conducted as part of the school's science curriculum while others were conducted as an after-school enrichment or co-curricular activity. In terms of learning outcome, one school focuses on science process skills; another focuses on scientific knowledge and the third focuses on environmental issues.

In this interactive session, the goal is thus to present boundary object as a methodological concept to understand how the different stakeholders work together to create a different KB-NLC program in their school, yet with resemblance of the KB-NLC community. In doing so, we also present three case studies of KB-NLC as exemplars of the productive negotiation among us.

### Description of the Three Orientations of KB-NLC Program

Three orientations of KB-NLC emerged from the design research project – knowledge orientation, process-orientation and affective-orientation. The following sections provide a brief description of each of the orientations.

### **(1) Knowledge-oriented Approach**

A knowledge-oriented approach was observed to arise from two of the participating schools. In this approach, the trigger that began their knowledge building tends to be an everyday process that students were familiar with. Examples include decomposition of meat and germination of seeds. Students working in this orientation would be focusing on advancing knowledge-based ideas such as cause-effect (e.g., “small seeds germinate faster than big seeds”) and reasoning (e.g., “maggots are produced by the process of abiogenesis”). The students working in this mode then conducted experiments to test their hypothesis. For example, students used a large number of seeds of varying sizes and compared their rates of germination to find out if small seeds germinate faster than big seeds. They then proposed reasons to support this hypothesis and compared their ideas with those found in the Internet and through interviews with their family members, for instance. The result of this knowledge-oriented approach was a set of generalized knowledge about the phenomena studied. For example, the group of students working on the decomposition of meat came up with a set of generalized characteristics of decomposition after they extended their investigations to test the ideas about decomposition of meat to other organic matter such as dead plants and other animals.

### **(2) Process-oriented Approach**

While the knowledge-oriented approach focused on constructing new understanding about a phenomenon, a process-oriented approach focused on constructing new understanding of the science inquiry process, even though both might have been initially triggered by puzzlement over some phenomena. However, the talk in this approach tended to be focused on how to improve the science experimentation process so that evidences generated could be improved. Some process-based ideas include the concept of fair test and control. The rise above of the knowledge building endeavor included improved experimental design and processes.

### **(3) Affective-oriented Approach**

The affective-oriented approach might look similar to a problem-based approach in the sense that students often work on trying to solve a more practical problem (e.g., reason for fishes’ death in the tank kept in the classroom). The knowledge building component emerged from the need to find reasons for the problem (e.g., what led to the fishes’ death in the fish tank). The students would propose possible causes and reasons (e.g., too much food in the fish tank could lead the fishes’ death as the food caused a change in the pH level of water). Investigations were carried out to test their hypotheses (e.g., using a pH sensor to track the changes in pH level over a period of time with tanks of different amount of fish food). Following the establishment of the cause of the problem would be to extend it to the problem context in which this knowledge building arose. The result could be an improved understanding of the effects of one’s action on the environment or in society.

## **Format of the Interactive Session**

The activities of the interactive session will include an introduction of the CSCL project and boundary object as a methodological concept, followed by a series of short presentations by partnering schools of their KB\_NLC program.

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## Getting Started and Sustaining Knowledge Building

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**Abstract:** Knowledge Building pedagogy (Scardamalia & Bereiter, 1996) offers a Knowledge Age framework for education by supporting students' capacity for innovation. Students work in a community, building on each other's knowledge, exploring and refining each other's theories, and engaging in the progressive improvement of their ideas. This knowledge work is supported by Knowledge Forum (Scardamalia, 2004) - the online environment that provides scaffolding supports for idea development. Teachers who are eager to explore Knowledge Building pedagogy and Knowledge Forum technology in their classrooms may not know where to begin, and application of Knowledge Building principles may not be obvious. To aid their process of invention, examples of Knowledge Building principles in action should prove helpful. The goal of this session is to provide such examples, and to collectively develop effective strategies, curriculum and resources that would allow newcomers to get started with Knowledge Building.

### Focus of the Session

Knowledge Building pedagogy (Scardamalia & Bereiter, 1996; 2003) offers a Knowledge Age framework for education by supporting students' capacity for innovation. Instead of simply learning about science, history, literature, etc., students engage ideas as scientists, historians, writers, and so forth. They work in a community, building on each other's knowledge, exploring and refining each other's theories, and engaging in the progressive improvement of their ideas. This knowledge work is supported by Knowledge Forum (Scardamalia, 2004) - the online environment that provides scaffolding supports for idea development, graphical means for viewing and reconstructing ideas from multiple perspectives, and a variety of other functions that contribute to collaborative knowledge building.

Teachers who are eager to explore Knowledge Building pedagogy and Knowledge Forum technology in their classrooms may not know where to begin, and application of Knowledge Building principles may not be obvious. To aid the process of invention, examples of Knowledge Building principles in action in a variety of contexts should prove helpful, as we collectively refine our understanding of education for a Knowledge Age. The goal of this session is therefore to provide examples of getting started with Knowledge Building pedagogy and technology, and also to collectively develop effective strategies, curriculum and resources to allow newcomers to get started. Questions to be addressed include: What resources do we need to help schools operate as knowledge-building communities? How can teachers build a community to support each other and innovation in education? How can researchers and teachers collaborate to promote idea generation, diversity, and sharing? What forms of interaction will support careful listening and refinement of ideas so that students engage in idea improvement with self-direction? What scaffolds will support increasingly high-level cognitive functions? These and other issues will be discussed and recommendations will be provided for enhancing and sustaining effective knowledge building discourse in school. The session will bring together researchers, teachers and school principals from Canada, Singapore, and the United States who have different, but complimentary perspectives on how to get started with Knowledge Building.



## Contributors and Design Sessions

### Knowledge Building in Senior Kindergarten and Grade 1 (Maria Chuy, Christian Tarchi, Monica Resendes & Bodong Chen)

If we ask a teacher who is experienced in the Knowledge Building approach “How and when do we get started with Knowledge Building?” the answer may well be “in Kindergarten.” As illustration to this answer, an example of successful implementation of Knowledge Building will be provided, using the classroom observations from the Laboratory School at the Dr. Eric Jackman Institute of Child Study<sup>1</sup>. In this school, children are introduced to knowledge building principles when they first enter the school at the age of three. The process of playing with ideas is natural in children, and is often exhibited as soon as children learn to speak. And expression and discussion of their ideas can be vehicles to deeper knowledge and understanding; so-called “misconceptions” are better thought of as “improvable ideas” (see Zhang, Scardamalia, Lamon, Messina & Reeve, 2007) and basis for conceptual change (Vosniadou, 2008) rather than “mistakes.”

As part of this session, researchers from the Institute for Knowledge Innovation and Technology<sup>2</sup> will trace the work of two experienced teachers in order to (i) illustrate how knowledge building discourse can be initiated as early as Senior Kindergarten, through a process of playing with ideas that is natural in children, and (ii) demonstrate how Knowledge Forum can be introduced in Grade One, when students are just starting to read and write. Key classroom activities will be described that demonstrate strategies teachers use to build effective Knowledge Forum discussions at this young age. The session will include video recordings of teachers' reflections and transcriptions of classroom discussions.

### Challenges and Strategies for Effective Knowledge Building in Elementary School: Principals' Perspective (Elizabeth Morley & Richard Messina)

Teacher development is essential for successful implementation of Knowledge Building pedagogy and technology. Elizabeth Morley, principal of the Dr. Eric Jackman Institute of Child Study<sup>1</sup>, will discuss effective procedures for introducing new teachers to Knowledge Building. She will also provide an account of the evolution of Knowledge Building practices over a decade, with indication of how core knowledge building principles such as *idea diversity* and *improvable ideas* allow for shifts that have enabled substantial knowledge advances in scientific, graphical, textual, and dialogic literacy associated with Knowledge Building practices. Strategies for engaging newcomers into an already functioning knowledge building community will also be discussed.

Richard Messina, an experienced Knowledge Building teacher and now vice-principal of the Dr. Eric Jackman Institute of Child Study<sup>1</sup>, will reflect on challenges to be expected along the thorny but fruitful path to Knowledge Building in elementary and secondary schools. Challenges and barriers to be discussed include a questions such as: How can we shift from “correct” to “improvable” ideas, so that children focus on advancing ideas rather than avoiding expression of wrong ideas? How can we help teachers to understand *epistemic agency* principle, so that they turn over their high level executive processes to students?

### Designing a Knowledge Building Curriculum (Katerine Bielaczyc & Teachers from Townsville Primary School, Singapore, TBA)

In order to have students going beyond learning *about* science to learning *how to engage as scientists*, a new school curriculum is needed. Through her project, entitled “Spreading Ideas: Creating Point-at-able Models of 21st Century education”<sup>3</sup>, Katerine Bielaczyc will address this question and reflect on the ways to cultivate a knowledge-building community in a classroom. The session will include onsite participation of teachers from Townsville Primary School (Singapore) who are creating a new science curriculum and Knowledge Building models in Singapore. This curriculum would enable students to go beyond limits of their knowledge and function in a manner similar to the scientific community.

This session will be extended into a broader discussion around curriculum of international open courses with emphasis on knowledge creation. Toward this end participants of the session will be positioned to identify environments and technologies that foster knowledge creation, and to discuss theories, pedagogies, and technologies that advance that goal.

### Knowledge Building International: Open International Courses, Innovation, and Resources (Marlene Scardamalia, Carl Bereiter, Monica Resendes & Stian Håkleiv)

The movement toward open innovation and resources has the potential to democratize educational innovation, but to accomplish that it must extend beyond resources for individual learners and teachers to a coherent system of interaction and feedback to support knowledge-building communities. Today's best practices won't be tomorrow's; effective team action will enhance and surpass individual achievements. Thus, cultivating a liking for advancing the community enterprise and increasing the pace of innovation while reducing barriers to change

is essential. Quality assurance requires new assessment and feedback tools in the hands of users, and it calls for international courses to engage teams of teachers, researchers and engineers in a collaborative process of invention, evaluation, and refinement. We provide a brief overview of proposed open and free resources to be offered through a new association: Knowledge Building International. During the session we will provide a brief overview and handout. We will then address your issues and questions during the discussion.

### Discussion (Jianwei Zhang)

As Discussant, Jianwei Zhang will synthesize the outcomes of the session, discuss the *principle versus procedure* dichotomy in educational approaches, and more generally reflect on the potential of Knowledge Building pedagogy and Knowledge Forum technology for education in a Knowledge Age.

### Endnotes

- (1) Official website of the laboratory school at the Dr. Eric Jackman Institute of Child Study, OISE/University of Toronto, Canada: <http://www.oise.utoronto.ca/ics/>
- (2) Official website of the Institute for Knowledge Innovation and Technology, OISE/University of Toronto, Canada: <http://www.ikit.org/>
- (3) Official website of the “Spreading Ideas: Creating Point-at-able Models of 21<sup>st</sup> Century education” project, Learning Sciences Lab, Nanyang Technological University, Singapore: <http://isl.nie.edu.sg/projects/spreading-ideas-creating-point-at-able-models-of-21st-century-education>

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## Collaborative Virtual Worlds and Productive Failure: Design Research with Multi-disciplinary Pedagogical, Technical and Graphics, and Learning Research Teams

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**Abstract:** This session reports on an ongoing project funded by the Australian Research Council's Discovery initiative that is conducting design research into learning in collaborative virtual worlds (CVW). The session will describe three design components of the project: (a) pedagogical design, (b) technical and graphics design, and (c) learning research design. The perspectives of each design team will be discussed and how the three teams worked together to create the project's CVW. The development of productive failure learning activities for the CVW will be discussed, and there will be an interactive demonstration of the project's CVW.

### Description

This session reported on an ongoing project funded by the Australian Research Council's Discovery initiative. Its aim was to investigate learning in collaborative virtual worlds (CVW) in terms of three central research questions:

1. How might learners construct deep and transferable understandings of important and challenging scientific knowledge and inquiry skills through specifically designed pedagogical experiences involving CVWs?
2. Might activities for learning science that involve CVEs motivate students to learn scientific knowledge and inquiry skills as well as to develop positive attitudes and predispositions towards science?
3. What types of pedagogical shifts will teachers experience when teaching with CVEs and what types of professional development and support will they need in order to effectively integrate and use CVE systems in their classrooms?

The methodological framework underlying this project is *design research* involving the use of a CVW (described below) in secondary science classrooms. Design research conducts formative studies in real world contexts such as classroom environments that test an innovative theory or research based educational design, and that in turn iteratively refines the design of the learning environment over time (Brown, 1992; Collins, Joseph, & Bielaczyc, 2004). In terms of learning theory, the design of the technology and the curriculum are informed by general learning sciences theories such as situated cognition (Brown, Collins, & Duguid, 1989) and distributed cognition (Salomon, 1993) as well as what might be called "focused" cognitive theories of conceptual change (diSessa, 2006), transfer (Bransford & Schwartz, 1999; Gick & Holyoak, 1987), and productive failure (Kapur, 2008).

There are three main design phases of this project. First, the *pedagogical* design phase has been shaped by meetings with various stakeholders in the project from the beginning of the proposal writing and is actively continuing as the project nears the end of its first year. In late 2008, the research team met with secondary science teachers from two schools where discussions were held about what subjects the teachers felt were challenging and difficult for students to learn, where topics were mentioned such as ecosystems, evolution, genetics, electricity, and chemical equilibrium. As part of these meetings, the teachers were shown and some were able to use the Virtual Singapura multi-user virtual environment that had been developed in earlier research in Singapore (Jacobson, Kim, Miao, Shen, & Chavez, 2010). The research team explained that the proposal would obtain funding to develop a new collaborative virtual world (CVW) that would be based on curriculum topics in New South Wales (NSW), as well as to align with the topics in a new Australian national curriculum that was being discussed and developed at that time (and is now being implemented).

Once funding was obtained, the *pedagogical design team* began meetings with a core group consisting of learning scientists, a university biologist, teacher education and learning technology researchers, and graduate students. The team came up this basic scenario for the CVW:

You and your team are scientists working for the Interplanetary Environmental Investigation Agency (IEIA). Your assignment is to investigate environmental issues on different planets

that have been reported to IEIA. Your team is visiting “Omosa,” a terrestrial class planet, where the Laok people live. They have reported that the populations of certain species of megafauna—an important food source in their society—were declining. Your team’s job is use your scientific knowledge and inquiry skills to conduct investigations into possible reasons for this decline Your team will make a report to the IEIA and to the Laok people on the results of your investigation and suggest possible ways to respond to this environmental challenge.

Working with Charlotte, the biologist and content expert, and with feedback from teachers, the pedagogical design team identified a number of conceptual dimensions of ecosystems and food webs that aligned with the new Australian secondary science curriculum and the curriculum currently being taught in secondary schools in NSW, as well as the main aspects of conducting scientific inquiry (e.g., hypothesis generation, dependent and independent variables, data collection, analysis and interpretation, reporting).

Concurrent with the work of the pedagogical design team, Debbie led the *technical and graphics design team* at Macquarie University, which consists of a computer scientist, graphic artist, and computer programmer who are creating the immersive 3D CVW using Unity3D. Bi-weekly meetings were held, some face to face and some using Web-based video conferencing software, where the pedagogical and technical and graphics design teams discussed issues about how the scenario and learning activities could be brought to “virtual life.” Figure 1 shows two screen shots from an early version of the Omosa CVW.



Figure 1. Screen Shots of Omosa: Tani of the Laok People (Top) and Grazing Herbivores (Bottom).

The *learning research design team* is led by Michael, and its members overlap with the pedagogical design team. The main task of this team is to ensure that the research questions of the project are systematically investigated and the reports, papers, chapters, and so on are prepared for dissemination. Of particular relevance to this project is a recently articulated learning sciences pedagogical approach—productive failure (Kapur, 2008, 2010)—that is being used to inform the design of the learning activities in the Omosa CVW to investigate the first two research questions. Situative and sociocognitive theoretical perspectives in the learning sciences (Bransford, Brown, Cocking, & Donovan, 2000; Brown et al., 1989; Sawyer, 2006) and conventional teaching practices tend to initially provide learners who are involved with learning challenging knowledge or solving problems with greater amounts of structure, which are removed over time with the intent of minimizing student failures and frustrations. “Structure” may be broadly conceived in a variety of forms such as structuring a problem, scaffolding, instructional facilitation, providing tools or expert help, and so on. Indeed, a substantial amount of research has examined the effects of structuring and scaffolding learners within ill-structured problem-solving activities (Puntambekar & Hübscher, 2005). However, there is research that suggests this

theoretical and a “common sense” perspective may not always be most efficacious for deeper learning outcomes or preparations for knowledge transfer in new problem solving situations (for a discussion, see Kapur (2008)). This project will conduct a program of research in which learning activities being designed for the Omosa CVW will initially challenge the learners with open-ended, low-structure tasks that they will likely struggle with or even fail at, followed by high-structured experiences (e.g., direct instruction by a teacher, worksheets, scaffolding provided in the CVW by intelligent agents). This pedagogical design may be characterized as a low-to-high structure (LHS) trajectory, which sharply contrasts with the more typical high-to-low structure (HLS) activities such as guided inquiry that are used in most other educational virtual learning research (e.g., Barab, Warren, & Ingram-Goble, 2006; Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005). During year two, the research plans are to conduct a quasi-experimental study with a LHS productive failure experimental condition and a guided inquiry HLS comparison condition. We expect to find higher-level gains on declarative knowledge assessments and higher performance in near and far transfer problem-solving tasks by participants in the LHS experimental condition. In order to understand process dimensions of learning, there will also be audio and screen recordings of a small number of students as they collaboratively work with the Omosa CVW, classroom qualitative observations, and interviews with students and teachers following the intervention. Based on these findings and suggestions, the Omosa CVW will be revised and decisions made about the appropriate next stages for research in year three of the project. An additional school will be included in the year three research, with planning meetings with these teachers beginning in 2011.

### Session Themes and Outcomes

The main session theme is *collaborative design teams for collaborative learning*. We view the process of developing innovative collaborative learning technologies as one in which multi-disciplinary perspectives are required with iterative feedback, advice, and suggestions from all relevant stakeholders. However, there are very real challenges with bringing together professionals who have very different content backgrounds and epistemic assumptions embedded in the discipline specific conduct of their respective crafts. For example, the pedagogical design team began with very *general* narrative of the scenario for the CVW that was to be elaborated on and made more specific over time with feedback from teachers and other members of the project team. However, the technical and graphics design team felt frustrated initially as they typically start projects with very *detailed* specifications. An expect outcome for participants in this session to appreciate that in collaborative designs, the different design teams and stakeholders need to respect each others perspectives and styles of working, while also not being threatened by the diversity of the disciplinary ways of working and communicating.

Another important session theme is *design research to foster innovations in learning technologies*. Design research has many advantages for researchers interested in better understanding how people learn. We also believe it is a powerful methodology to help create and iteratively revise and enhance new types of learning experiences mediated by rich affordances and interactive capabilities enabled by increasingly powerful and affordable technologies.

The final session theme is *design research for buy in*. By this we mean the overall planning, development, implementation, research findings, and final project deliverables that are intended to create a collaborative learning innovation that the users of the innovation—the teachers and students—actually want to use. By listening to teachers and state education agency staff from the very beginning of the conceptualization of the project and the proposal writing, we tried to identify real problems that teachers and education agency staff have, and to shape the trajectory of design decisions in ways that will hopefully help create viable solutions to their problems. Also, teachers know their students have trouble learning threshold concepts and skills in science (Meyer & Land, 2005). We hope the rigorous research design we have in place will generate a range of quantitative and qualitative information that future teachers could examine and then (hopefully) decide to try using one of our collaborative virtual worlds with their students. For staff in education agencies and at policy levels, their problems are having an appropriate range of information to make decisions about resources to provide in schools (e.g., particular types of technologies and networking infrastructures), data about learning costs/benefits associated with a potential new learning innovation to perhaps recommend for wider scale implementation in the educational system, and so on. Consequently, another outcome is for participants to appreciate that it is important for design researchers and teams to think broadly and to plan carefully. Overall, we hope that this will be a valuable session for participants as it will share real world case experiences from a design-based research and development team that is linking theory to practice so that research outcomes in the classroom will inform our theories of learning and technology design, as well as create viable and robust learning modules based on collaborative virtual worlds for use in science classroom settings in Australia and internationally.

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## An Interactive Research Experience with Mobile Biology Games

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**Abstract:** Research shows that educational games can help students build content knowledge and skills but it can be difficult for teachers to effectively integrate game-based learning into their existing curriculum. UbiqGames are browser-based, casual games that relate directly to the curriculum but can be played outside of class time. Designed for mobile devices, the games can be accessed anywhere, anytime and discussed or analyzed back in class. The UbiqBio project is a research study around four UbiqGames designed to teach intro biology concepts. Participants in this interactive conference event will take part in a real-time research experience by playing a biology game with varying amounts of previous content knowledge. This will provide an opportunity to try out one of the games, experience the ubiquitous learning games format, and gain new perspectives on the issues at play when it comes to implementing educational mobile games in the classroom.

### The UbiqGames Genre

A growing body of research (Prensky, 2001; Gee, 2003; Shaffer, 2006) argues that games can be powerful tools for motivating and engaging players, and for developing useful habits of mind as well as domain-specific content knowledge. Games can also be effective teaching tools from which students can transfer knowledge and experience gained in the game environment to another context (Gee, 2003).

Teachers must motivate their students with various extrinsic or intrinsic factors but one benefit of games as teaching tools is that aside from beating the game or scoring points, the process of playing the game itself is fun (Prensky, 2002). This is due in part to the idea that gameplay is one way to reach a state of flow, the feeling of exhilaration and deep enjoyment (Csikszentmihaly, 1990). Research has also found that the most motivating and engaging games are the ones that have a balance of “hard fun” (Papert, 1996), which challenges the player to actively participate in order to learn and master the activity. As a result of this type of game, players are not only engaged during the time they’re playing the game, but they are also motivated to continue to play and engage with the content over time.

Many studies have been done on video games, simulations, and other forms of computer assisted instruction, which have shown encouraging results. Work by Vogel et. al. (2006) analyzed 32 empirical studies and showed reliably across these studies that attitudes toward learning after using computerized simulations or games were better than those of students who were taught using only traditional methods. Baranowski et. al. (2008) examined health-related video games and stories and found that they led to various desirable outcomes such as knowledge increases, attitude shifts, and behavior changes. As well, Baranowski’s research suggested that games do indeed help to drive interest in academic topics. These and other meta-analyses (Bayraktar, 2002; Christmann and Badgett, 1999) show that good video games and technology-based activities can indeed help students engage with and build skills related to content.

While potential benefits can come from playing educational games, effectively integrating digital game-based learning into formal education can be challenging. Given already limited instructional time, adding games to the curriculum can be difficult. Moreover, teachers often have limited access to hardware. Many educational games also have a long and/or steep learning curve, and can therefore be intimidating, especially to some teachers.

But not all games fit this mold. With growing recognition of their popularity, so-called “casual games” (Juil, 2009) are different from many traditional electronic (educational) games. Casual games are typically played in sporadic bursts, have simple rules, and are designed for a broad audience to enjoy with a small initial investment of time or learning of rules. The casual style of gaming has inspired researchers (e.g., Klopfer, 2008) to develop new generations of educational casual games, designed specifically to provide simple, easily accessible, yet rich experiences for players and teachers alike.

Casual educational games in general, and the Ubiquitous Games developed by Klopfer et al. in particular, take advantage of their format to engage players with content related to their classroom studies. Ubiquitous Games (aka UbiqGames) are web-based, casual games designed to be played primarily on mobile devices, but able to be played on any computer with a web browser. On a practical level, by making the games ubiquitous (able to be played on handheld computers as well as desktops and laptops), researchers hope to break down some of the barriers to adoption (Klopfer, 2008). UbiqGames are meant to be learning games, but are not meant to replace classroom instruction. Instead, by being casual games that can be played in the interstitial times of the day, UbiqGames are meant to enhance existing classroom instruction. Theoretically, there are several learning advantages that come by virtue of UbiqGames’ casual play style. First, there is the opportunity that

players have for background processing of the material with which they are engaging. Though players will not spend all of their time between game sessions thinking about the material, they will spend some, which increases their time engaged with that material. A related opportunity is the chance to build experience, expertise, and knowledge over time. Rather than playing in one prolonged event, “beating” the game, and disengaging with whatever material they might learn from the game, students playing casual games are invited to engage with material repeatedly over time, which leads to greater opportunity to construct complex knowledge.

Related to, but distinct from this point, is an important design consideration for Ubiquitous Games that sets them apart from many other casual games. In addition to affording casual game play outside of class, UbiqGames explicitly build in reflection tools that a teacher can take advantage of in a more formal setting, i.e. in class. By building tools for reflection on the experiences they have with the material in the games, the designers of UbiqGames hope to take advantage of experiential learning, in which a learner has concrete experiences, reflects on those experiences, and thereby builds more abstract understandings (Kolb, 1984).

## The UbiqBio Project

The Ubiquitous Games for Biology (UbiqBio) project, funded by a grant from the NIH, is a web-based mobile simulation game platform designed to help high school introductory biology students (typically 9th and 10th graders) understand important biology concepts with which they often struggle. In addition to a general lack of “scientific literacy” in the US, empirical studies indicate that traditional curricular approaches leave gaps in the domain specific knowledge of many middle and high school biology students (Brown, 1990; Ferrari & Chi, 1998; Lewis & Wood-Robinson, 2000). In order to address this, the UbiqBio project utilizes technology to engage students and promote deep learning of science concepts.

The project encompasses development of four UbiqBio games as well as research on the week-long implementation of each game, during which students are equipped with web-enabled smartphones which they carry with them throughout the day. The four games are designed to connect ideas across scales and subdisciplines, including Mendelian genetics, protein synthesis, evolution, and ecology. Teachers see classmates interacting as parts of a simulated biological system, while the students see themselves “playing” their part in a large-scale, multi-day, whole-class simulation game. (These games can in fact be accessed from any full-fledged web browser, making them truly hardware independent and therefore “ubiquitous”). Each UbiqBio Game is designed to be highly engaging, almost addictively so, such that students “play” the game outside of class, in small increments of time (3-5 minutes) in nondisruptive ways between classes, before or after school, and in the evening as homework. As students play the game, data from the whole class is wirelessly transmitted to a central computer which aggregates the real-time data. Teachers and researchers can log into a simple yet powerful UbiqBio Teacher Portal site to track student progress, identify students who are not doing their “homework”, and access the data generated by their students’ game play. Since game play largely takes place outside of class, teachers spend class periods using real data drawn from their class’s gameplay as the basis for lessons where concepts are developed through analysis of data, hypothesis formation and group discussions.

The science content in the four UbiqBio units, which span the life science curriculum from genetics to evolution, is closely tied to Massachusetts and national standards, and derived from a core set of topics that are fundamental to an appreciation of modern biology and associated with powerful misconceptions that block a student’s understanding of these critical ideas. The activities, supplementary materials, and assessments are classroom ready. Equipment set up and management is simple, and games can be played on devices that students have or will have in the near future. These range from cell phones to netbooks to desktop computers. Games are fun and easy to learn, yet require strategies that teach, explain, and reinforce challenging core biology concepts. Students participate willingly and teachers find it exciting to augment student learning with these highly motivating tools.

The research questions we are exploring in this project focus on student learning and engagement, as well as teacher adoption and usability. Six teachers in the Boston area are incorporating UbiqBio games into their curricula this year, lending smartphones to their students and having them play each game as they teach the corresponding topic. Data collection includes statistics logged during gameplay, teacher and student interviews and observations, and a biology content assessment administered to experimental and control groups. By examining all of these aspects, we hope to learn more about students’ play patterns with mobile games and their effectiveness in solidifying content knowledge.

## Beetle Breeders

One of the UbiqBio games we have developed is called Beetle Breeders (see Figure 1), which focuses on the concepts of Mendelian genetics and inheritance patterns. In this game, players are running a beetle pet shop. Customers want to buy beetles with certain traits and it’s the players’ job to breed them. They choose the contracts they want to work on, then mate the right beetles to produce the desired offspring. They must use their



knowledge of Mendelian genetics to work with increasingly difficult patterns of inheritance and maximize their profits. Within each class, students see who can earn the most money in the beetle business!



Figure 1. Beetle Breeders Screen Shot.

Preliminary data and anecdotal findings from student groups that have begun participation in the study have shown that students are motivated by the game's entrepreneurial goals. On their way to finding success in the game, they get significant practice with concepts involving genotype, phenotype, and Punnett squares, and they engage more often and more deeply with the biology topic.

### CSCL Interactive Event

The interactive event we are planning for the conference has three main goals.

- We will showcase the UbiqBio games, making them accessible to practitioners and others interested in mobile learning.
- Through video footage, we will hear from biology teachers and students, who have participated in the study and used UbiqBio games in their class, about what they see as the successes and challenges of this type of learning tool.
- In addition, event participants will be part of a real-time research project that explores one of the core questions of mobile learning games: how should games fit into existing curriculum and content learning?

Schedule permitting, the event will take place over two separate sessions, one at the beginning of the conference, and one at the end, as well as during interstitial moments throughout the conference. At the introductory session, attendees will become familiar with the genre of UbiqGames, our UbiqBio project, and the Beetle Breeders game in particular. They will also have a chance to hear from some of the Boston-area teachers who have already used UbiqBio games in their classes. We will then split the participants into two groups, in preparation for the mini-research project in which everyone will be taking part. Half of the group will leave the session, not receiving the content lesson. The other half will stay for an explanation of genetics and inheritance patterns, the science content in Beetle Breeders, to ensure that they have prior knowledge when they begin to play. After the session, both groups will play Beetle Breeders on their own smartphones or laptops, advancing as far in the game as they wish. The group that didn't receive the lesson will be learning the concepts as they play, and the other group will be putting their existing knowledge into practice by achieving goals in the game.

At the wrap-up session, both groups will have had ample time to experience the game and think about ways to implement it in a classroom. We will hear some reflections from a few representatives of each group to get a sense of the similarities and differences between their experiences, and whether that was affected by their prior content knowledge, or lack thereof. We will then facilitate discussion on UbiqGames in general, and more specifically on the context in which they can be used in an educational setting. Learning games can be used by students in many ways – from gaining their first exposure to a topic, to demonstrating their mastery of it, and

every step in between – but the implementation and curriculum around the game should be designed to reflect that context. Attendees will have time to discuss the merits of various strategies, how best to design collaborative games to suit certain purposes, and the pros and cons of implementing each variety.

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## Collaborative Design (CODE) As a Teacher Professional Development Model in Francophone and Anglophone Quebec

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**Abstract:** Teacher professional development as collaborative design (TPD-CODE) is fostered in network-enabled university-school partnerships. We reflect on two initiatives sponsored by the Quebec Ministry of Education, and coordinated by a knowledge transfer organization (CEFRIO). Their activity systems are based in two different cultures: The Francophone and the Anglophone Quebec cultures, Canada. Both initiatives afford school teams an opportunity to enhance their practices and broaden the horizons of both classes and schools. In the Remote Networked Schools (RNS) initiative, teachers, students and researchers use the same online tools (iVisit, VIA and Knowledge Forum). In the BCT (Building Community through Telecollaboration) initiative tools vary to a greater extent. We illustrate what TPD-CODE can be as we describe the interactions that are taking place in these activity systems in which teachers engaged K-12 learners into networked learning through the use of collaborative technologies.

The purpose of this paper is to offer new thoughts on teacher professional development in complex ecologies. Professional development is enacted as collaborative design (TPD-CODE), and is illustrated here through an analysis of the interactions that occur within two activity systems, the *Remote Networked Schools (RNS)* francophone initiative and the *Building Community through Collaboration (BCT)* Anglophone initiative. The RNS initiative began in 2002 and is in its fifth phase of development (2010-2011). Its goal is to enrich the learning environment of small rural schools. The BCT project is a province-wide initiative with teachers and administrators from English school boards across Quebec. Its main goal is to encourage, facilitate and support collaboration among students, teachers and educational leaders to enhance learning across the community.

### Conceptual Background

Teacher professional development, collaboration, design and technology have been associated in a number of ways in the past fifteen years: Loucks-Horsley, Hewson, Love, and Stiles (1997) published an influential book, *Designing professional development for teachers of science and mathematics*; Dufour and Eaker (1998) launched an increasingly popular movement, professional learning communities; Wenger (1998) published *Communities of practice* and inspired the design of a growing number of onsite/online teacher professional communities; Lieberman (1996, 2000) documented teacher networks for educational reform; Marx, Blumenfeld, Krajcik, and Soloway (1998) wrote a powerful article on New technologies for teacher professional development; and Glazer and Hannafin (2006) provided an understanding of how reciprocal interactions influence professional learning. Our own reflective practice as teacher educators in participatory modes (Silva & Breuleux, 1994; Breuleux, Erickson, Laferrière, & Lamon, 2002; Laferrière & Breuleux, 2006) led to the understanding of teacher professional development as collaborative design (TPD-CODE).

When approached from recent social and cultural theories of learning and cognition and their applications (Barab, Kling, & Gray, 2004; Bransford, Brown, & Cocking, 1999; Engeström, 1987; Hollan, Hutchins & Kirsh, 2000; Lave & Wenger, 1991; Lave & Chaiklin, 1993; Salomon, 1993; Stahl, 2006; Scardamalia & Bereiter, 1994, 2004, 2006) the focus of teacher professional development is not the individual performance or the development of an individual's generic competence (applicable to all situations) but rather the collective performance and the development of "colocated competencies" shared among a group of individuals. *Learning in a distributed way through a historically developing activity in a concrete setting or context* became the cornerstone of our two initiatives. It involved a particular activity, the use and mastery of multifaceted cultural tools (ICTs) by K-12 teachers wanting to engage learners in cooperative and collaborative inquiry within and across schools. Our analysis focuses on the interactions that took place within and between constituents (or sub-systems: the university-school partnership, the classroom community, and the online collaborative space) for teacher professional development to transform into collaborative design.

### Methodology

One of the comprehensive approaches is cultural-historical activity theory (Lim, 2002; Bernhard, 2007). We adopted Engeström's (1987) framework, but limited our analysis to the interactions within and between three constituents of the activity systems (the university-school partnership, the classroom community, and the online

collaborative space). Moreover, we focused on the third phase of the RNS activity system (2006-2008), one carried out in over 80 schools operated by 22 different school boards. Its aim was the improvement of small rural schools' learning environment. Top-down and bottom-up processes had been deployed for conditions of innovation (Ely, 1990) to exist (Turcotte & Hamel, 2008). As for the BCT project, it was initiated in 2007 along with a design research approach (Bereiter, 2005; Brown, 1992; Collins, Joseph, & Bielaczyc, 2004; Schoenfeld, 2006), highlighting iterative processes of research (i.e., design – evaluation – revision) and mutual close collaboration between teachers, administrators, a University-based research team, and a support team. Through the iterative processes, the design research approach has evolved since 2009 toward participatory design research (Silva & Breuleux, 1994), which emphasizes the engagement of users / participants in the design process.

### Participants

Participants were volunteer teachers working in network-enabled classrooms. They were also school and school district administrators. They were from numerous sites, and mostly elementary schools. The RNS research-intervention team was composed of a CEFRIO representative, teacher educators and researchers from four different universities. In the BCT initiative they were from the same university.

### Collaborative Technologies

Collaborative tools were used to support the design of new forms of learning. The collaborative platform chosen for the RNS initiative is the result of more than two decades of analysis of the process of expertise and innovation, involving cognitive and computer scientists and practitioners, with social innovation (Knowledge Building, Scardamalia and Bereiter, 2004) and technology innovation (Knowledge Forum, Scardamalia and Bereiter, 1994) reciprocally linked and both central to the classroom agenda. This suite of tools includes a web-based collaborative platform for extending and deepening classroom discourse, which affords scaffolds to support written discourse, and a set of analytical measures that participants and classroom-based communities can apply to monitor their own knowledge building activity.

SAKAI was the learning management system (LMS) adopted by the BCT community to help instructors, researchers, and students create websites for collaboration. Since September 2009, a space for the BCT community was created and we have used it (a) to cultivate the community of practice (Wenger, 1998) for BCT teachers and educational leaders (i.e., shared vision and shared repertoire); (b) to provide an online space where BCT teachers and educational leaders can share experiences, thoughts, knowledge, and resources in relation to their professional practice; (c) to allow BCT teachers and educational leaders to engage in open and sustainable communication and collaboration; and hence (d) to foster a culture of sharing and create shared repertoire within the BCT community. Each Cycle 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.

### Activity Systems

The two initiatives were themselves nested in the context of an ongoing reform initiated ten years ago, spanning the entire K-12 curriculum, and influenced by social-constructivist conceptual and pedagogical approaches. They were conceived as ways of implementing the reform through onsite/online collaborative design. The partnership structure, including the Ministry's involvement, created a change context: all actors, from teacher to superintendent, as well as parents and community organizations, were informed and involved in the initiative. At the intervention level, the following design principles guided actors within the activity systems:

- **Ease of access.** Networked computers and online resources and tools need to be accessible without losing much time once basic technical skills are mastered.
- **Multi-modal social interactions.** Educators and learners meet face-to-face. Teacher educators and teachers also meet online, pursuing locally grounded activities or geographically extended activities.
- **Active collaborative learning.** Teachers' networked classrooms foster peer interaction in the pursuit of projects and inquiries, rather than individual learning where students/pupils work on computers learning rote knowledge and specific skills.
- **Collaborative knowledge building.** Meaning is negotiated and collective ways of understanding complex problems emerge and evolve.

The reflective practitioner approach (Schön, 1983) was endemic to the way professional development was conceived by the research-intervention team. For example, baseline data was provided to teachers regarding their students' use of Knowledge Forum (notes written and read, length of threads, scaffolds used, etc.), and specific qualitative analyses were conducted (e.g., questions asked by students, levels of explanation reached). At the end of each cycle of activity, new intervention-oriented questions were identified with participating teachers and a new iteration was launched.

At the research level, ethnographic data regarding university-school partnership was gathered through participant observation. Questionnaire and interview data was analyzed along with online verbal and written discourse to study onsite/online interactions that characterized professional development within each activity system. Applying Engeström's (1987) framework, sociocultural accounts were developed to identify the characteristics of the interactions taking place within and between constituents (or sub-systems): the university-school partnership, the classroom community, and the online collaborative space.

## **Results**

### **Interactions within the University-school Partnership**

#### Sustained Interaction

Interaction is sustained as steering committees, coordinating body (CEFRIO) and research teams interact with school district and school leaders and personnel on a regular basis (new role and routine).

#### Inclusion

Participants are prompted to develop images of their networked collaborative learning environment – as the object-outcome of the design activity. Depending on the dynamics at each site (school school district, local community), there are classroom students, school and school district personnel, local community members, parents and social leaders who submit ideas.

#### Negotiated Goals

The research-intervention team values the use of online collaborative tools for deepening understanding of authentic problems. Participating teachers are primarily engaged in making sense of new technology use in the classroom. Through onsite/online interaction with members of their local school district and of the research-intervention team, object-outcomes emerge.

#### Learning by Design

Participating teachers cooperate and collaborate with one another onsite/online to plan and conduct specific learning activities and projects for and with their students (new roles and routines). Design does not depend only on technology as some teachers with lesser connectivity engage school learners in collaborative inquiry projects of a greater complexity than some with better connectivity. Teachers' online classroom activities (new artifacts) serve as exemplars to incoming teachers seeking ways to use online tools in their own classroom.

### **Interaction within and beyond the Networked Classroom Community**

#### Rotation

Learners from one grade may be involved in individual tasks while others work at the computer searching for information or interacting with peers at distance.

#### Cooperation

Cooperative learning practices in place are extended online: one student helping another with math problems, students making short presentations, small groups presenting the outcomes of their projects to a remote classroom (new artifacts, roles and routines).

#### Collaborative Inquiry

The learning community model is new to almost all teachers. It means engaging students in collaborative inquiry (new roles and routines). The online component tends to involve students from two different classrooms working together in teams. The underlying knowledge building principles did not get fully understood by a majority of teachers but a few of them are largely applied: real ideas/authentic problems, diversity of ideas, constructive use of authoritative sources, and rise above.

### **Interaction within the Online Collaborative Space**

#### Joint Design Space

Online conversations unfold. For instance, there is always someone from the research-intervention team available on the videoconferencing system (iVisit), for providing technical and pedagogical support and guidance (new role, new routine).

### Accumulation of Artifacts

As the repertoire of activities develops, communities' artifacts also develop. Experienced teachers have evidence to show when incoming teachers express doubts about the students' overall capacity to engage in inquiry with others at a distance.

### Boundary Spanning

Incoming participants (substitute teachers, beginning teachers, experienced teachers) are enculturated into the emerging networked school cultures: teachers teaching other teachers about engaging students in authentic questioning and collaborative inquiry across classrooms; school learners describing to substitute teachers what they had just done online with their regular teacher (new roles and routines). Teacher educators and teachers also push the boundaries of their own individual teaching and that of their collaborators (new roles and routines) as they encounter real and authentic new problems (technological, pedagogical) in their practices of use.

### **Discussion**

Collaborative design (CODE) takes shape as interaction intensifies and endures between research and intervention in real contexts. Putnam and Borko (2000) called on teacher educators for approaching teacher professional development from the teachings of the new learning sciences. CODE has been in the making for years. The two initiatives just described contributed to its articulation: a university-school partnership, a networked classroom communities, and an online collaborative space. Within each sub-system, characteristics of interaction emerged: 1) the university-school partnership's interactions demonstrate sustainability, inclusion, and shared goals; 2) the networked classroom community's interactions occur on a rotating basis and manifest cooperation and/or collaborative inquiry/knowledge building; 3) the online collaborative space is a space for joint design, accumulation of artifacts, and boundary spanning. We suggest that teacher participation in the design of an online collaborative space is critical to the design of the networked classroom community. Strong university-school partnerships provide the necessary anchorage.

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## Knowledge Building Teacher Network (KBTN) in Hong Kong: Sustaining and Scaling up Knowledge Building through Principle-based Innovation

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**Abstract:** This CSCL event is designed to introduce knowledge building model and practice (Scardamalia & Bereiter, 2006), to showcase teacher innovation situated in a knowledge building teacher network (KBTN), to explore principle-based innovation for teacher development, and to provide an opportunity for community dialogue about issues of CSCL research and sustained innovation in classrooms. With an increasing number of teachers implementing knowledge building, it may be fruitful to explore the experience of KBTN, with many new teachers coming together to work on knowledge building. How do Hong Kong teachers understand, adapt and implement the innovation in relation to the socio-cultural context with much emphasis on examination? How might teachers and researchers tackle tensions between scaling up versus lethal mutation, a common problem when teachers merely follow surface activities? This CSCL practitioner event examines successes and barriers, and explores principle-based innovation for tackling the challenges of classroom innovation from both practitioner and researcher perspectives.

### Introduction

The knowledge building educational model, first developed in the 1980s (Scardamalia & Bereiter, 2006), has been of interest to many researchers and practitioners around the world. Scardamalia and Bereiter postulate the model emphasizing collective efforts for knowledge production and knowledge creation dynamics for 21<sup>st</sup> century education. While schooling focuses on tasks, knowledge building focuses on ideas, with dynamics of epistemic agency, idea improvement, and the advancement of community knowledge. The annual Summer Institute of knowledge building regularly attracts researchers, teachers, teacher educators, scientists from North and Central America, the Asian Pacific regions, and Europe. The knowledge building team at the University of Toronto has developed an international network – The Institute for Knowledge Innovation and Technology (IKIT) that consists of multi-disciplinary teams of researchers, scientists, teachers, engineers, and policy-makers from worldwide. Hong Kong is one of IKIT's key knowledge building research and practice sites, and now developing a teacher network for scaling and sustaining knowledge building practice in classrooms.

The Knowledge Building Teacher Network (KBTN) first began in Hong Kong with a teacher secondment scheme in 2006 and later expanded with the School-University Partnership project, funded by the Education Bureau (Ministry of Education in Hong Kong). KBTN, led by the first author, hosted in the Centre for Information and Technology in Education (CITE), currently has approximately 70 teachers working on the implementation of an educational model of knowledge-building. The macro-context of educational reform for 'learning how to learn' in Hong Kong encourages schools to engage in new projects for pedagogical and technological improvements. These conditions, in turn, facilitate the growth of the meso-structure of a teacher network in which researchers work with practitioners to advance knowledge building theory, pedagogy and analyses against the background of the socio-cultural-historical contexts of Asian classrooms.

Since the early 2000s, researchers in Hong Kong have been conducting research on knowledge building in classrooms. In 2006, KBTN was first developed to scale up and sustain knowledge building innovation to a range of classrooms. The initial network consisted of 7 experienced teachers 'seconded' from the Education Bureau and more than 20 new teachers recruited from different subject areas and school levels (Grade 5-12, ages 10-16). A special feature of KBTN is its partnership with the government and schools. Through this partnership, seconded teachers' salaries were paid by the Education Bureau, with 50% of their time released from school duties to work directly on the knowledge building project. Most of the first batch of seconded teachers had successfully conducted knowledge building in their own classrooms; they now joined together to work collectively providing peer support and developing knowledge building classroom innovation.

The teacher secondment project (2006-2008) was a welcomed success to the Education Bureau and a larger grant has been obtained for further scaling up with the University-School Partnership project since 2008. Considerable work has been conducted to develop links among different levels (i.e., macro, meso and micro) of the systems such as aligning the requirements and needs of the Education Bureau, school leaders, and teachers for classroom innovation; designing knowledge building approaches to meet the assessment and examination demands prevalent in Asian schools; and helping teachers to understand and foster changes through student knowledge building inquiry.



A key idea of KBTN is that teachers would engage in collective inquiry and building knowledge together as what they would intend their students to develop. Further, an emphasis is placed upon the design for a hybrid teacher-researcher collaborative culture to tackle common problems of understanding (Bereiter, 2002). Various designs are included: 1) *design meetings* in which seconded teachers work with the researchers to engage in knowledge building discourse and to inquire into their knowledge building practices; (2) *area-based meetings* when teachers of similar subject areas, led by seconded teachers, meet to plan the principle-based curriculum; (3) university-based *workshops* among all of the network teachers for collective problem-solving; (4) *school visits*, during which seconded teachers support and mentor new teachers, with the support of the design team. Community-building is enhanced when teachers visit one another to share classroom practice; (5) *technology support* with the use of Knowledge Forum (KF) as a design space for teachers to build knowledge; and (6) *dissemination workshops* for the public in alignment with the educational reform goals of Hong Kong. Although these are common-place activities in teacher development projects, as we will discuss later in detail, a key emphasis is placed upon using knowledge building principles for research-based classroom innovation.

Project evaluations demonstrated various positive aspects. In terms of *breadth*, there is growth in terms of the number and expertise of teachers. For example, the network has increased from 30 to now 70 teachers with around 50 KF databases, suggesting that most teachers have spent a dedicated amount of time trying out the innovation. The number of experienced teachers serving as seconded teachers and teacher associates has increased from 7 to now 15; more than 25 teachers have been sustaining the innovation in the classroom over 3 years and several over 6 years. While there is considerable variation, some have shown *depth of understanding*. Not only do teachers develop more understanding about knowledge building, they are *making shifts* and becoming change agents adapting the innovation and contributing to the knowledge creation process. For example, while knowledge building is mostly undertaken in the science curriculum, the KBTN teachers have developed ways to examine knowledge building principles in the Language and Humanities curriculum. In particular, KBTN supports teacher growth and the transformation of teaching expertise into a community property through our increasing number of open classes for observation and shared KF databases.

Another important development is our international collaboration of students and teachers with other knowledge building networks from around the world. Some KBTN teachers joined the Summer Institute in Toronto and several are engaged in the Knowledge-Building International Projects (KBIP) within a multi-national collaborative knowledge building network working with teachers from Quebec, Barcelona, Toronto and Mexico. This event on the local network (KBTN) will be linked to another one on KBIP to demonstrate the notion of networks of networks for symmetrical advances.

For further information, please refer to the KBTN Website at <http://kbtn-resources.cite.hku.hk/>

## Theme of the Session and Expected Outcome(s)

### Scaling and Sustaining Knowledge-Building Practices and Principle-Based Innovation

This CSCL practice event is to introduce knowledge building practice to newcomers, to showcase KBTN teacher innovation, and to provide an opportunity for community dialogue about issues and challenges facing CSCL classroom innovation. With an increasing number of school systems around the world implementing the knowledge building model, it would be fruitful to explore the experience of KBTN, with so many teachers coming together working on knowledge building. How is it possible to implement, sustain and scale up knowledge building? How do Hong Kong teachers adapt and sustain the innovation in relation to the socio-cultural context with much emphasis on examination? How might teachers and researchers tackle the tensions between scaling up versus lethal mutation, a common problem when teachers merely follow surface activities (Brown & Campione, 1996)? This CSCL practitioner event examines successes and barriers, and explores principle-based innovation for tackling the challenges of classroom innovation from both practitioner and researcher perspectives.

Scardamalia and Bereiter (2006, 2007) stress the need to place principles at the forefront in teacher development. While many programs focus on helping teachers learn some pedagogy and tools, we argue for the importance of teachers understanding of the knowledge building principles. The idea is that teachers need to know how as well as why the principles, so they can understand and implement innovation with a sense of ownership, and thus be able to sustain and adapt across contexts. In the early years, KBTN teachers were mostly concerned with infrastructures and lesson plans; but over the years, increased design efforts were put to principle-based innovation. Apparently it is not possible to work with teachers without classroom activities; however, there is a difference in focus. For example, when KBTN teachers provided examples of classroom events, they were encouraged to consider the episode as an object of inquiry, using the KB principles as the analytical lens, rather than merely focusing on teaching activities. For Asian teachers who are used to structures and activities, the experiences of moving towards principles are challenging and fascinating.

While there have been many analyses on knowledge building, this CSCL event, conducted by local KBTN teachers and students in Hong Kong, joined by the international CSCL and knowledge building communities, may provide enriched perspectives on knowledge building innovation. The principle-based approach has been well developed in Toronto classrooms over some years. KBTN is relatively new and it would be useful to examine how teachers with less experience from different educational systems may implement principle-based innovation. In this event, we will hear from teachers how they come to understand the knowledge building principles, how they adapt the knowledge building practice in Asian classrooms, what impacts knowledge building and principles have on their students, what they consider to be success factors and why they continue with the project, and how they tackle challenges and barriers etc. Students from Hong Kong classrooms will also discuss and showcase their work, and policy makers/officers from the Education Bureau (Ministry) will also be invited to join the event. Together researchers and practitioners explore the following questions:

- What is teachers' experience of KBTN? Why do they engage in classroom innovation (or join the project)? What makes them continue/sustain their knowledge building practice?
- How do teachers think about knowledge building principles? How do they come to understand something as complex as knowledge building? How do they see their own changes or growth?
- How are knowledge building principles developed in different curriculum areas? While knowledge building is mostly implemented in science curriculum, how do teachers design knowledge building in Language and Humanities curriculum? And how is it related to the socio-cultural educational contexts?
- How does principle-based innovation work in Hong Kong classrooms? What are the impacts on students' knowledge advances? How does teachers' understanding of student growth sustain knowledge-building innovation?
- What is the role of assessment in principle-based innovation? How does assessment of knowledge-building principles work?
- How are knowledge building principles developed within an examination-oriented curriculum? How do teachers implement innovation in light of socio-cultural influences and constraints?

### **Expected Outcomes**

1. To share experiences, questions, and challenges among practitioners and researchers when implementing principle-based innovation from around the world.
2. To increase knowledge of the specific ways in which principle-based innovation can be implemented in a variety of educational contexts with case examples from the different socio-cultural context of Hong Kong.
3. To gather feedback regarding the specific ways in which principle-based innovation can be implemented for formative evaluation and design efforts towards sustained knowledge building innovation.
4. To increase practitioners' understanding of principle-based innovation for developing a knowledge community of practice, through the sharing of best practice exemplars and a pedagogical discourse that can facilitate professional growth and possibly change, enhanced by technology.
5. To develop some understanding regarding successes and barriers for scaling up and sustaining classroom innovation.
6. To examine CSCL practice-research synergy and explore how practitioners and researchers can work collectively and collaboratively to advance their knowledge.
7. To build communities across different networks internationally focusing on classroom innovation.

## Session Activities — Brief Rundown of Each of the Activities to be Conducted in Sequence, with Focus, Time Schedule and Participants Involved

	Session Activities
1.	Introduction to the Knowledge Building Teacher Network (KBTN)
2.	Fire-hose presentation: Each poster presenter will give a 1-2 minute presentation to introduce their poster.
3.	<p>Interactive Posters: Each team of presenters will set up a station showing their posters, power points with classroom videos, KF databases, teachers'/students' work examples, etc. The interactive posters will include the following areas of inquiry:</p> <ul style="list-style-type: none"> <li>• Teacher Experience and Change Towards Principle-Based Innovation</li> <li>• Principle-Based Innovation and Curriculum Design in Language and Humanities</li> <li>• Sustaining Knowledge Building Innovation and Examination Culture</li> <li>• Students Assessing their Knowledge Building Using Principles</li> </ul> <p>Groups of students will also set up stations to showcase their knowledge building experiences and work examples.</p>
4.	Conversations with KBTN teachers and students from local schools
5.	<p>Panel discussion:</p> <p>Therese Laferriere, Laval University, Quebec;  Elizabeth Morley, Institute of Child Studies; University of Toronto;  Jan van Aalst, University of Hong Kong;  Jianwei Zhang, University at Albany, New York</p>
6.	Open Discussion

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## Orchestrating Collaborative Science Curriculum across Formal and Informal Contexts

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**Abstract:** This demonstration presents an evolving body of work around the development of a new open source framework for smart classrooms – known as Sail Smart Space (S3) – that supports research of complex pedagogical configurations, emphasizing student collaborations, emergent knowledge repositories, and real-time semantic analysis of student data. The project involves the development of Physics curriculum in two diverse classroom settings: a first year college Physics course and a grade 12 advanced placement physics class. This session will acquaint attendees with the iterations and refinement involved in bringing such a curriculum into a classroom, and the unique opportunities such environments afford researchers and teachers. The presentation will provide a brief history of the project to its present state both technically and pedagogically; followed up by a hands-on demonstration of the current iteration; and closes with a series of videos and discussions about our vision of the future of the S3.

### Introduction

The purpose of this demonstration is to present an evolving body of work around the development of a new open source framework for smart classrooms – known as Sail Smart Space (S3) – that supports research of complex pedagogical configurations, emphasizing student collaborations, emergent knowledge repositories, and real-time semantic analysis of student data. The current project involves two research teams working at the University of Toronto and Dawson College in Montreal in the development of Physics curriculum for enactment in two diverse classroom settings: a first year college Physics course and a grade 12 advanced placement physics class. The goal of this session is to acquaint attendees with the successive iterations and refinement involved in bring such a curriculum into a classroom, and the unique opportunities such environments afford researchers and teachers in the orchestration of collaborative activities for students. The presentation will begin with a brief history of the successive implementations of the project to its present state both technically and pedagogically; this will be followed up by a hands-on demonstration of the current iteration with attendees; and will close with a series of videos and discussions about our vision of the future of the S3 platform and a question and discussion session with the audience.

### Theoretical Background for Project

#### Developing Environments for 21<sup>st</sup> Century Learning

The everyday lives of children are increasingly being shaped and mediated by technology; and yet, the schools tasked with educating these children have been largely untouched by the evolving digital landscape (Buckingham, 2007; Tyack and Cuban, 1999; diSessa, 2000). A recent report on cyberlearning (NSF, 2008) concluded that a lack of deliberate efforts to coordinate technology into science and math curriculum could seriously hinder students, in terms of their success in related careers, and more generally in becoming productive members in a modern technological society.

Creating an environment where the production, assessment, and aggregation of content results from the contributions of all members of the community rather than from a single authoritative source, mirrors the types of interactions with technology that students are often faced with outside of the classroom (e.g. Flickr, YouTube, Facebook). Implementing such a “socially oriented” model of classroom instruction (Ullrich et al., 2008) can enable students to take more active roles in the classroom environment and to become creative producers of their own curriculum content (Buckingham 2007; Ito et al., 2009). Introducing digital media into the learning environment can free students from traditional “canned lab” approaches, and embed problem-solving activities in more deeply collaborative curriculum (Slotta & Linn, 2009; Soloway et. al, 1999). Complicating the successful integration of these kinds of technologies into classroom curriculum is that most educators are not sufficiently familiar with new pedagogical models of technology-enhanced learning (Ertmer, 1999; Slotta and Linn, 2009). Additionally, those developing technology environments for learning often do not have the pedagogical understanding to develop effective applications for their products (i.e., the use of “smartboards” and clickers, which are typically left to the teachers to determine how best to use them). This issue can be particularly problematic if not properly implemented due to the significant costs in both resources and class time in introducing these kinds of environments into a classroom setting.

In response to this challenge a central goal of this research has been to bridge the gap between technology and pedagogy, working closely with teachers, in the development of learning spaces that harness technology to provide powerful new opportunities for students and teachers alike.

### Scripting Learning across Contexts

Developing curriculum in a technology enhanced learning environment can allow for the real-time tracking of the products of student interaction across a variety of contexts (formal/informal environments) and configurations (individual/small group/whole class interactions), giving teachers and researchers new opportunities to design the ways in which students interact with the curriculum. The intentional orchestration of the nature and timing of activities, as well as the particular roles that each student plays within the larger curriculum is often compared to that of a theatrical script (O'Donnell & Dansereau, 1992). To be effective, the design of these scripts must take into account the unique contexts in which each of these activities takes place. Individual actions – such as asking a question, answering a question, and the evaluation of answers – may all take place at different times and locations, effecting how students understand and process an activity (Lemke, 2000). Careful scripting of a curriculum can help insure that the natural granularity of the individual tasks matches the granularity that is most beneficial to student learning (Dillenbourg & Jerman, 2007). Scripting can also build time and opportunities for reflection (O'Donnell & Dansereau, 1992) which not only help students build their own personally relevant understandings from their educational experiences (Bransford et al., 1999; Krajcik et al., 2008; Linn and Eylon, 2006), but can also provide rich data for teachers to gain insight into students' understandings of the curriculum. Access to student ideas during instruction can allow teachers to adjust their instruction “on the fly” to more effectively aid students in overcoming misconceptions or developing deeper understandings of the curriculum under investigation (Dillenbourg & Jerman, 2007).

### Description of the Learning Environment and Project Iterations

#### Developing a Technology Rich Learning Environment

New forms of knowledge media and data repositories offer a wealth of opportunity for researchers and curriculum designers who can take advantage of the varying contexts (i.e., within the classroom, at home, or in field activities) and devices (e.g., laptops, smartphones, interactive tabletops, and large format displays). This new functionality allows for exciting new kinds of instruction where students collaborate across contexts, dynamically generate knowledge, build on peers' ideas, and investigate questions as a knowledge community.

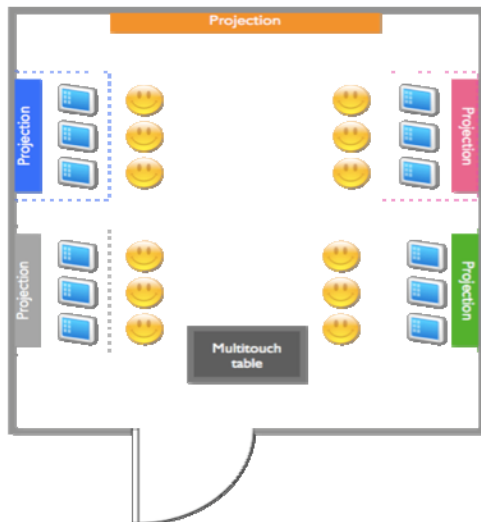


Figure 1. S3 Smart Classroom Setup.

Architecture for Interactive Learning – Slotta & Aleahmad, 2009). S3 specifies a framework in which devices and displays are configured, building on 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). The current S3 smart classroom implementation involves four large projected displays in each corner of a classroom, a fifth, larger, multi-touch display on the

This research recognizes the potential of technology enhanced learning environments to enable such pedagogical models. To this end, we have advance the notion of a “smart classroom,” which employs a wide range of technologies for investigating a full spectrum of collaborative inquiry and knowledge construction activities. The work centers around the development of a powerful, flexible open source platform called

SAIL Smart Space (S3), which in turn builds on the rich framework of SAIL (Scalable

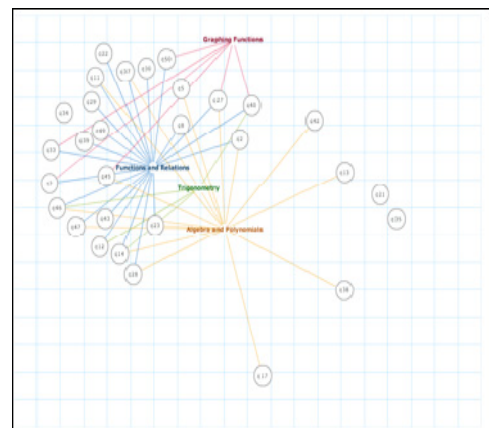


Figure 2. Sample of aggregated display of labels resulting from multiple student groups' tags.

front wall, a multi-touch table, and twenty laptops – all interconnected via high-speed wireless network (Figure 1).

### Iteration 1: Aggregated Visualizations in a Math Curriculum

Our original implementation of S3 involved a grade 12 high achieving Math class ( $n = 19$ ) in an urban high school. Working closely with a Math teacher at the school using a co-design approach (Penuel, Roschelle, & Shechtman, 2007). The curriculum project responded to the math teacher's concern that students did not grasp the interconnections between branches of mathematics, instead perceiving math as consisting of discrete elements (e.g., Algebra, Graphing Functions, Polynomials, and Exponentials) as represented in textbook chapters. Within the S3 classroom students individually logged into laptops, were automatically grouped and placed at one of the room's visualization displays, and asked to "tag" (label) a total of 30 questions. Each group's display showed a graphical visualization of their responses. Students were then asked to collaboratively solve their tagged questions and vote and comment on the validity of other groups' tags. A central display showed a larger real-time aggregate of the all groups' tags as a collective association of links (Figure 2). As students voted on these tags, positive votes resulted in thicker link lines than those that fostered disagreement. As a result of the activity, students' math connections more closely corresponded with those of the teacher. Further, the high variability of students' connections within individual problems (observed during the pre-test) diminished during the curriculum and on a subsequent post-test (Tissenbaum & Slotta, 2009).

### Iteration 2: A New Kind of Physics Lesson

Our second implementation of S3 involved two grade 12 Physics classes ( $n = 32$ ), engaged in a similar form of problem sorting, tagging and solving, but with adaptations that responded to the findings from the previous cycle, while extending the design to the domain of physics problem solving. For this design students were sorted into four groups and each student in the group was assigned four out of sixteen total multiple-choice conceptual physics problems to individually solve and tag. Once the first step was completed, students remained in their groups and were shown four of the questions along with the aggregate of the whole class' answers and asked to form a consensus concerning a

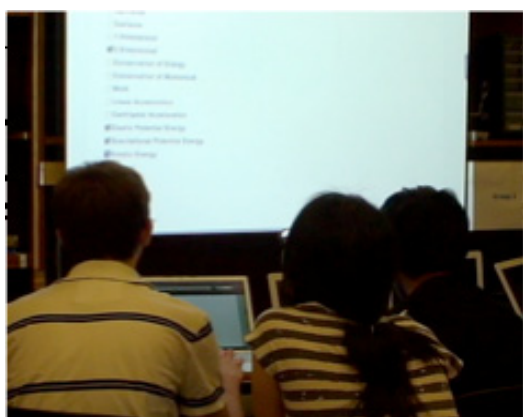


Figure 3. Students selecting elements during the group review activity using the large shared display.

“final answer” and a final set of tags, along with a rationale for their choices. A final step involved the groups being given a longer physics problem and being asked to choose which of the four provided concepts questions was best suited to helping them solve the longer problem. Findings from this study showed that the accuracy and structuredness of the element tagging by the students working in groups across both classes was closer to the expert model than as individuals. Average accuracy scores were 80.94% (groups) compared to 76.57% (individuals), although the difference was only marginally significant. In terms of structuredness, groups (69.73%) significantly outperformed individuals (50.11%) by 19.62%,  $F(1, 30) = 10.756$ ,  $p = 0.003$  (Lui, Tissenbaum & Slotta, accepted).

### Current Iteration: Real-Time Reporting for Curriculum Orchestration

The current iteration of the S3 environment is similar to iteration two in its content and student grouping, however the curriculum has been extended to include a more complete “teacher portal” for designing and viewing student interactions, and has added informal learning contexts into the initial problem solving stage. The newly designed portal will allow teachers to upload, order, and set the answers for the problems to be used in each run of the curriculum (Figure 4). Teachers can set up multiple conditions for each class or for different classes simultaneously. Unlike in previous iterations, students will now be able to access the individual problem solving activity at home (Figure 5), to be used as a launching point for the next day's activities. All of the individual students answers, reflections, and tags will be collected and uploaded to the server and the aggregate of the students' responses will be available to the teacher at any time (see Figure 6). In this way when planning the next class' lesson the teacher can adapt it to address any conceptual misconceptions the class may have.

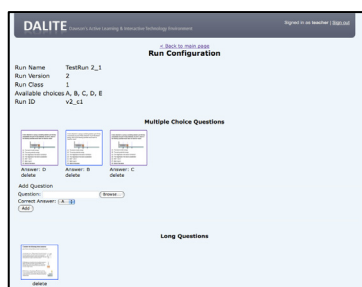


Figure 4. Teacher Design Space.

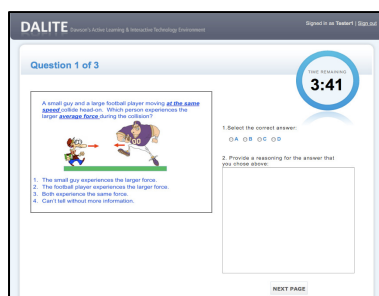


Figure 5. Individual Problem Solving Stage.

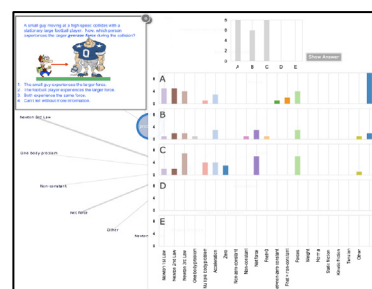


Figure 6. Teacher Visualization.

For the in class activities the system has been adapted to offer the teacher more flexibility within the script to either offer a short, targeted lecture that clarify concepts that students may have shown difficulties with, or to have students go right into the group work activity. Furthermore, the curriculum provides a more opportunities for the teacher to adapt the script between questions based on the real-time reports her or she receives from the system during the group activities.

### Engaging Participants with Current Design

This stage of the presentation will engage the audience in a run through of the current curriculum design – giving them a chance to log in, answer questions individually, and work in groups to form a consensus based on the audience’s answers – mimicking an authentic classroom situation. The aggregated product of the audience’s answers, using the teacher visualization, will be projected at the front of the room to further simulate an authentic class setting, and will also provide the presenter (playing the role of the teacher) the ability to adapt the script based on the actions of the audience.

### Future Developments of the S3 Environment

The final section of the presentation will show case a demo video that highlights where we envision the future development of the S3 environment. The first shows a portion of an extended activity in which the current iteration of Physics problem solving provides the backdrop for an inquiry activity in which the S3 classroom’s large screens to display examples of the course content captured by the class in informal settings (such as at home, in the playground, or in the city) using smartphones. Then by using the classroom’s touch surfaces, the students collaboratively negotiate correlations between the artifacts and the grounded theory, helping students make a deeper connection between the in-class content and the “real-world”.

### Questions, Discussion, and Feedback

#### Note on Format:

We would like to engage one of the teachers who has enacted this curriculum to discuss the different ways in which they have used the curriculum with their students; however, it will largely depend on the time of the presentation as the time difference between Hong Kong and Toronto (13 hours) will make coordination difficult. If this is possible we will fold this portion into the timing of the “Future Developments” and “Question, Discussion, and Feedback” portions of the event.

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## Using Google Sites in Collaborative Inquiry Project-based Learning

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**Abstract:** Dr. Samuel Kai Wah Chu and his research team, who have experience in implementing inquiry project-based learning (IPjBL) with Wiki to four local primary schools, will demonstrate their way of using Google Sites in IPjBL. This session aims to stimulate discussion among researchers and educators on using Wiki to enhance collaboration among students in IPjBL.

### Theme

The demonstration will be based on the experience gained in the QEF project titled “Promoting a collaborative teaching approach to inquiry project-based learning with Web 2.0 at upper primary levels”. The project involves implementation of Google Sites—a free and user-friendly Wiki platform—to Primary 5 students in their inquiry based project in General Studies.

A considerable body of research studies has indicated that inquiry project-based learning (IPjBL) is a far more effective mode of learning than traditional forms of learning. The benefits of IPjBL include the integration of knowledge across disciplines, cultivation of students’ spontaneous curiosity, and development of learning that respects both the intellectual growth and age-specific concerns of students (Dewey, as cited in Dow, 1999, p. 7). IPjBL can also help students develop their critical thinking and problem solving skills, as well as the ability to communicate and collaborate with others (Chu, 2009).

To further benefit students in their inquiry learning, Web 2.0 technologies can be used in conjunction with the IPjBL approach. Students can learn new ways to co-construct group project in the cyberspace. During the process of comprehending, locating, analyzing, evaluating, and synthesizing information, students can apply their knowledge for problem solving in their inquiry projects and, hence, enhancing their information literacy and media literacy (Chu, 2009).

Among all Web 2.0 technologies, Wiki is the most suitable tool for students to do their group project collaboratively. Wikis are commonly used as knowledge management tools to facilitate the creation, sharing, discussion and revision of knowledge artifacts in group projects (Da Lio, Fraboni & Leo, 2005). Wiki software has been applied in various ways in education, including as support for writing individual and group projects, course management and distance education (Bold, 2006; Parker & Chao, 2007). Dr. Chu has conducted several researches on the use of Wiki to promote students’ learning and found that both undergraduate and postgraduate students were positive towards the effectiveness of Wiki in facilitating their group projects. In particular, Wiki was seen to enhance group collaboration as well as work quality, and it was considered a useful tool for knowledge management in terms of knowledge creation and sharing (Chu, 2008; Chu, Cheung, Ma & Leung, 2008).

In addition to providing an online collaborative environment for students to compile their group projects, Wiki enables teachers to scaffold students’ learning by frequently tracking students’ work and commenting on their work during different phases of the project.

Through implementing IPjBL with Wiki to four local primary schools, Dr. Chu has gained valuable experience in guiding teachers to make use of Google Sites in their teaching. In the demonstration, Dr. Chu and his research team will demonstrate their way of using Wiki in IPjBL. However, there is no single right way of using Wiki in IPjBL. Thus, this session aims to stimulate discussion among researchers and educators on using Wiki to enhance collaboration among students in IPjBL.

### Expected Outcomes

After the interactive session:

1. Educators and teachers who are not familiar with Wiki and IPjBL will learn to make use of the new techniques in their teaching.
2. Participants are expected to enhance their knowledge on Wiki and IPjBL through knowledge sharing.
3. The Wiki platform created by the research team can be improved for future use based on the comments of other researchers and practitioners.

## Programme Rundown

Activities	Person in charge
<ul style="list-style-type: none"> <li>● Introduction to the QEF project “Promoting a collaborative teaching approach to inquiry project-based learning with Web 2.0 at upper primary levels”</li> <li>● What is inquiry project based learning?</li> <li>● How can Web 2.0 tools, especially Wiki, help students in their collaborative inquiry project based learning?</li> </ul>	Dr. Samuel Kai Wah Chu
<ul style="list-style-type: none"> <li>● Introduction to Google Sites</li> <li>● Demonstration of using Google Sites in inquiry project</li> <li>● Sharing of Google Sites templates created by the research team</li> </ul>	Dr. Samuel Kai Wah Chu and research assistants
<ul style="list-style-type: none"> <li>● The participants will be grouped in several groups (3-4 per group) and they will try to use Google Sites to create a Wiki for collaboration.</li> </ul>	Dr. Samuel Kai Wah Chu and research assistants
<ul style="list-style-type: none"> <li>● Feedback and discussion</li> </ul>	Dr. Samuel Kai Wah Chu

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## Triological Learning Supported by Knowledge Practices Environment

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**Abstract:** Here is shortly presented an interactive session where Knowledge Practices Environment (KPE) is presented and demonstrated, as well as a learning approach called triological learning. The triological learning emphasizes students learning activities which are organized around shared “objects”. KPE is designed to support triological learning and collaborative knowledge creation processes. Both KPE and triological learning have been developed in a large EU-funded KP-Lab project (2006-2011). They will be elaborated during the session.

### Introduction – Main Features of the KP-Lab Project

KP-Lab project (5 year IST project co-funded by the European Community 2006-2011, ended at January 2011) has aimed at understanding how learners in educational and professional settings develop novel epistemic artefacts and transform their knowledge practices, collaboratively, in long-term processes. In addition, the project investigated how students in higher education do the same by cross-fertilizing professional and educational practices and solve complex, authentic problems with the help of innovative knowledge practices and educational technology. The theoretical approach has its background in the *knowledge creation metaphor* of learning. The knowledge creation metaphor emphasizes collaboration on developing some novel things, good representatives being the *knowledge building* approach, the *progressive inquiry* model, and the *expansive learning* (see Paavola et al 2004). The specific approach developed in the KP-Lab project is called ‘triological learning’, where the shared objects are the third element in addition to the individual work and participatory collaboration.

### Theory

The triological learning approach (Paavola & Hakkarainen, 2009) develops models and tools for supporting and arranging learners’ activities around shared ‘objects’ (such artefacts as texts, models, conceptual artefacts, but also practices and processes) that are created for some real purpose or subsequent use, which is often not the case in conventional educational practices. The focus on collaboration with shared objects and practices can be seen as a complement to the meaning making tradition in CSCL. Within the triological approach, individually performed activities and social interaction serve the longer-term processes of developing specific, concrete, shared objects. Shared epistemic objects and practices are not fixed objects with stable properties like materials typically used in educational settings, but open-ended, future oriented, and in the process of being defined by the participants (see Knorr-Cetina, 2001).

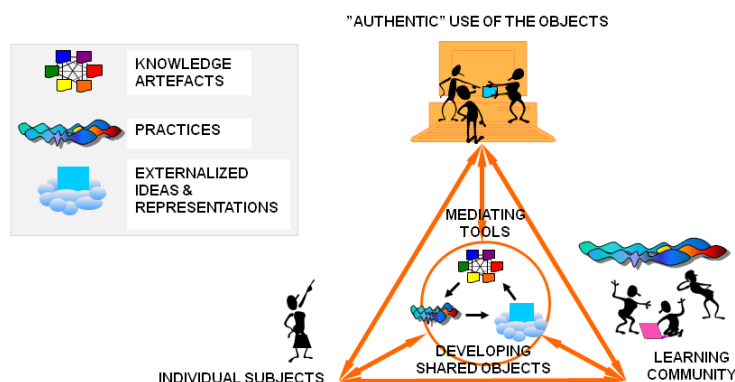


Figure 1. An Illustration of the Trialogical Approach to Learning Presenting Its Basic Elements (Paavola & Hakkarainen 2009).

## Pedagogy

In the KP-Lab project following design principles have been formulated to characterize trialogical learning.

1. Organizing activities around shared objects.
2. Supporting integration of personal and collective agency and work.
3. Emphasizing development and creativity on shared objects through transformations and reflection.
4. Fostering long-term processes of knowledge advancement with shared objects (artefacts and practices).
5. Promoting cross fertilization of various knowledge practices and artefacts across communities and institutions.
6. Providing flexible tools for developing artefacts and practices.

## Technology

Within KP-Lab, an open source collaborative learning environment, called Knowledge Practices Environment (KPE), has been developed in (see Lakkala et al, 2009). KPE is based on a visual desktop metaphor. Thus, allowing an easy manner to freely organise, re-structure and move the shared objects and chronological tasks as the users wish. Furthermore, there are no restricted rights according to preset categories, such as a teacher versus students. The users define themselves the rights and restrictions they need in their work. The already well-established features of collaborative environments are obviously present in KPE also. Such are: facilities for interacting with knowledge artefacts, processes, users, and reflective tools during a trialogical learning or working process.

The visual metaphor offers different perspectives to the same elements, called views:

1) The Process View presents students with a GANTT chart type of chronological display, which specifies the tasks students have set for themselves, milestones and allocated responsibilities. The Alternative Process View gives means for grouping the process more freely with elements chosen by the participants and tagging these, which allows filtering according to the tags.

2) The Content View presents users with a graphical representation of all the artefacts and their linkages, metadata and tags describing these artefacts, plus "tasks" provided by the users. Content items can be documents, wiki pages, web links, notes, sketches, and visual models, which can be commented as well as chatted by the users.

3) The Community View allows displaying the members visually in groups if the users have formed such groups. It also provides a description of all members of the particular shared space, explicating the tasks and content items created and responsibilities allocated for each member.

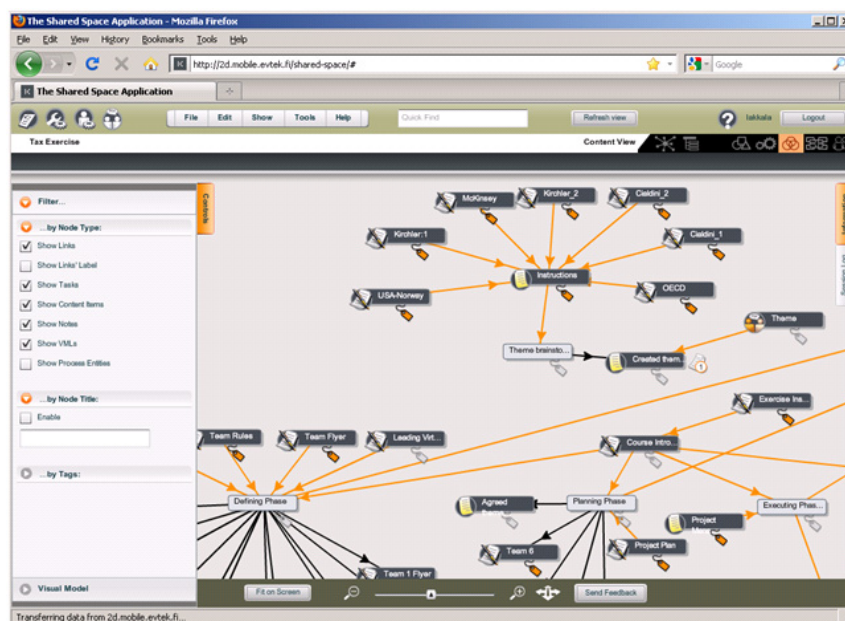


Figure 2. An Example of Content View in KPE.

## Co-design

The project had strong theoretical background, which produced the scope for the technical development. Design of KPE had its start on design principles of the triological learning (see above). The design principles served as a guide and as generic criteria in the design process in the sense that they enabled the creation of pedagogical scenarios which attempt to situate and contextualize the knowledge practices within particular educational contexts. Especially for technology development, it turned out early on in the project that other conceptual tools (like various “types of mediation”) besides design principles were needed. Ideas and requirements from practical cases and also from technology developers were provided. The central question was to articulate and specify advanced knowledge practices that are still emerging and in flux. The design solutions produced scenarios, design principles, and requirements for operationalizing the triological approach.

## Theme of the Session and Expected Outcome(s)

We present examples of usage and features of the KPE as pre-conference activity – actually in the KPE. During the interactive session, we make a short introduction to the triological learning approach and visit the ideas of the pre-conference activity. The aim of the session is to discuss and plan the different usage potentials with the participants of the session as well as the users and designers of the system attending virtually.

As an outcome, we anticipate to promote interaction between current and potential users (developers, teachers, students, researchers) and with pedagogical and technological developers from different countries. Further, various challenges and opportunities related to the triological learning approach and more generally co-design and pedagogical development activities will likely be generated and discussed.

## Before the CSCL-meeting

Material on experiences and comments concerning KPE will be collected to one shared space in KPE called “CSCL2011”. It will be open for anyone to join from:

<http://2d.mobile.evtek.fi/shared-space/>

Username: Student1, or: Student10, or: Student13

Password: 1234

And then search “CSCL2011”, e.g. with “Quick Find”, and double-click and you are in.

There will be some guidance to the use and features of KPE. We will also invite persons and organizations who have used KPE and been interested in KPE to add comments and materials (like short comments, or videos from users) before the meeting to be developed together. This focus with materials before the session is in line with the ideas of triological learning.

The comments of the users will be used in the 90 min session as a start to continue the discussion. Thus, the persons attending to the virtual pre-congress activity have a real potential to contribute to the future use and development.

## During the CSCL Session

There are teachers, students, developers, and researchers from Helsinki, Oslo, Stockholm, and Kiel available in their own countries who will be monitoring the group work, with participants at the CSCL, plus potential participants from other places invited to join through the net:

- 1) A short introduction on the ideas produced during the pre-congress activity as well as potentially some presentations on KPE tools, and on the triological learning. Slides on these will be produced to the shared space and there will be room for discussion and commenting.
- 2) Short slide shows on 2-3 courses where KPE and the triological approach have been used and applied. Teachers and students from these courses are available for answering questions and commenting their experiences.
- 3) Usage scenarios elaborated in small groups for using KPE and the triological approach. What advantages and challenges are to be seen? Groups are organized at the place of the CSCL session but remote participants can collaborate also through KPE. The group works are done at KPE.
- 4) Summarizing the results and answering questions. The small groups shortly present their main ideas. Answers and questions are collected for further use.

## Knowledge Practices Laboratory (KP-Lab) Project - Links

Website: <http://www.knowledgepractices.info>; <http://www.kp-lab.org>

Facebook: <http://www.facebook.com/group.php?gid=189181689732&v=wall>

Introductory video: <http://www.youtube.com/watch?v=k9CVmq3P00w>

Knowledge practices Environment: <http://2d.mobile.evtek.fi/shared-space/>

Partners, see: <http://www.kp-lab.org/partners>

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## Creativity of Teachers and Peer-Student-Tutors through Video Media at the Intersection of Content and Cognition

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**Abstract:** The primary theme of this interactive workshop is the collaborative exercise of creativity through video media at the intersection of content and cognition. The session focuses on the use of a) media tools for a large collaboration of teachers and student assistants in producing libraries of platform independent mathematics and science media and b) the Japanese lesson study collaboration model applied to video-mediated lessons. The workshop features an underlying framework involving a theory of personalized learning communities, hands-on activities by which participants engage in media creation activities, a simulated lesson study, and opportunities to pursue partnerships.

### Project Background

The project underlying the workshop involves seeks to explore and implement innovation in mathematics teacher professional development, teacher creativity, intergenerational CSCL, and digital libraries. The project is supported by the US Department of Education's Institute for Education Sciences (IES) (Hamilton & Harding, 2008) and the National Science Foundation (NSF) (Hamilton, 2010). The NSF portion of this work began in December, 2010, and includes the newly-forming repository where teachers and student content can be found, at <http://teacherscreate.org>. This site, while publicly available, is in the early stages of development as of December 2010. The research draws on multiple theoretical frameworks but also features repeated and stepwise alterations in design and implementation. (At a metalevel, for example, the more recently-funded NSF portion of the research is the result of iterations over the ongoing IES-supported research on collaborative workspaces, peer tutoring and pedagogical agents.) While the session and underlying project are primarily organized around mathematics education, the overall framework and the demonstrations are appropriate for other areas, especially including school science.

This CSCL workshop revolves around teachers and students collaboratively developing locally contextualized video media libraries for use in classroom and home settings. The libraries, while an important object of development, are of somewhat secondary importance in the IES and NSF supported research. Instead, that research focuses in part on **how teachers collectively evolve in expertise or develop in their sophistication through the process of producing and editing video**, and in jointly building libraries or repositories of content. They also focus on **leveraging and building the creativity of teachers in coherent communication of subtlety and nuance about mathematical and scientific structure**, and in avoiding or repairing misconceptions.

In this process, teachers become what we refer to as applied microgenetic analysts in using media tools to help advance student intuitions, formalisms and understandings of mathematical and scientific concepts (Hamilton & Harding, 2010). Beyond a focus on teacher development, the research also involves making digital media more usable in live classroom settings through a series of evolving design principles and in producing community digital repositories that are organized and used in a more locally contextualized manner than has been typically envisioned or implemented for open education resources. One of the greatest difficulties of the open education resource movement, we believe, has been the decoupling of resources from the contexts in which they are created in search of generalizability and highest usage. Our emphasis on a) customizing resource repositories jointly owned by its contributors and b) local teacher pedagogical development through content creativity shifts the emphasis to type and quality of local community usage as first priority.

### Peer-Student-Tutors

A second and newer part of this work involves the inclusion of high school students as co-creators with teachers of these videos and of the repository space. For the balance of this narrative, we refer to these individuals as "peer-student-tutors" who produce videos to distinguish them from students who view or use the videos in learning sequences but are not involved in their production. The interaction of teachers and peer-student-tutors entails profoundly rich intergenerational collaborations that we are just beginning to explore. It capitalizes on important findings in research areas that include worked examples, apprentice learning, and peer tutoring. The session includes participation by teachers and students from teacher-researcher partnerships supported by the previously referenced grants from the US Institute for Education Sciences (IES) (Hamilton & Harding, 2008) and National Science Foundation (NSF) (Hamilton, 2010). The underlying conjecture animating this effort is

Table 1: Workshop features.

Workshop Type →	CSCL in practice showcase; interactive and participatory demonstration
Topic	
Remote participants	Teachers and student-peer-tutors in Los Angeles and possibly east Africa, Mexico, or UK
Keywords:	Teacher creativity; intergenerational computer-supported collaborative learning; tacit knowledge; pedagogical content knowledge; teacher professional development; open education resources
Media:	Tablet computers; electronic writing pads usable in Macintosh and Windows; screen capture video production software; mobile devices that show video
Subject area	Primarily STEM fields, with emphasis on mathematics
Website	<a href="http://teacherscreate.org">http://teacherscreate.org</a>
Theory Frames	The underlying project is supported by a theory of personalized learning communities; research on lesson study; and research on open education resources.

that students' mathematical abilities and communication competencies improve when they create mathematical media that is peer-reviewed and developed in collaboration with teachers. The resulting repository is also a crucial interest. Based on pilot work, it is realistic to conjecture a significant value to teachers and to student peers from the availability of videos and other media that target specific topics. Testing these conjectures is the first of three project research goals. If the project continues to support or amplify these conjectures it can help us progress to important and exciting new roles and relationships in future learning environments, permitting those environments, including classrooms, to more routinely elicit creative competencies from everyone in them. While this effort seeks to position students in peer-tutor and instructional material maker responsibilities, it does not seek to have students eclipse or diminish the role of the teacher, a topic the workshop will explore with participating teachers and students. Instead, the project explores whether in measured fashion, teachers can draw students into a partnership to systematically help to scaffold learning by peers, and to forge new types of intergenerational collaboration and service learning. The potential upside for both teachers and their students is large. We expect teachers to have more locally contextualized resources instantaneously available to scaffold student learning, a greater sense of professional partnership with young adults, and more mental space and time for higher-order and imaginative effort in solving complex teaching challenges. We expect student-tutors to become more effective communicators and mathematics users, and we expect those using the media to have a greater repertoire of immediately usable resources produced specifically for their learning.

### Expected Outcomes of the Workshop

For the attendees, the workshop will

- show teachers and their university and research partners viable paths for using computer supported collaboration to exploit underutilized creative competencies in teaching – even when, and especially when -high stakes testing is part of the system context;
- show how to involve students in sophisticated peer teaching arrangement; and
- lead to additional research and practice partnerships.

Additionally, and in the spirit of Stahl and Hesse's observations about CSCL research carried out to refine CSCL theory (Stahl & Hesse, 2010), this CSCL-in-practice session will afford organizers insight, from attending practitioners and researchers, about reshaping the eclectic theoretical frameworks of the effort and implementation practices of the project.

### Workshop Part 1: Introductions and Topical Overview of Contributing Research Strands

Following an introduction of attendees and distribution of materials, we will introduce participants to several relatively disparate research strands. The intent is not to present an analytical overview but rather to establish a basis for the demonstrations and interactions to follow, and the basis from which research design iterations and refinements are carried out.

#### Teacher Creativity

We will emphasize the fact that while nurturing, enhancing mathematics teachers are expected to be conveyers rather than producers of curriculum materials. The prominent role of traditional textbook or reform curriculum producers and curriculum standards and policies, the lack of effective tools for digital representation of mathematics, and the very limited time that teachers have outside of the classroom, all act to crowd out the **creative potential** of teachers to generate content. Mathematics teachers are not expected to be content



*producers* but rather are content *conveyors*, following pre-defined curriculum in preparation for accountability tests. 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. This is all the more ironic given attention to research on creativity in students, in curriculum developers, and in school leaders. No US federal program or state program explicitly focuses on fostering or leveraging the imagination of teachers in formulation of content (Hamilton & Harding, 2010). Yet we have found that teachers possess enormous and underutilized reservoirs of creative energy, tacit knowledge, experience, and problem-solving ability about complex pedagogical challenges when furnished collaboration and media software tools – and the opportunity to use those tools.

We will include in this topical overview a summary of widely accepted definitions of creativity, variations that appear in this project, and efforts to build a research-based teacher creativity index.

### Challenges to Important Types of Usage of Open Education Resources (OER)

The second research thread involves an introduction to challenges in the development and use of digital repositories of educational objects such as applets or simulations. Digital repositories represent enormous potential in education for a broad spectrum of reasons. This portion of the conversation focuses only on the usability of such media in classroom or classroom-related activities (such as home study). Despite, for example, over \$100 million in investments in the US Science, Technology, Engineering and Mathematics (STEM) Digital Library (NSDL) program since 2000, the connection of such resources to learning, especially in classrooms, remains disappointingly remote, as the NSDL Program Announcement explains (National Science Foundation, 2010).

### Teacher Quality and Professional Development

The third thematic area in the introductory segment of the workshop relates to the primacy of teacher quality in learner experience and to the well-established importance of nurturing rich pedagogical content knowledge (“PCK”) in teachers that accommodates deep structural characteristics both of a content area and of student cognition (Ball et al., 2005; Gess-Newsome, 2002; Loucks-Horsley et al., 2003). This theme will also stress professional development through Japanese lesson study (Lewis, Perry, Hurd, & O’Connell, 2006) and highlight the fact that this important tool has not been widely researched for lessons that involve technological mediation (Lewis, 2010).

The fourth area involves important findings on the efficacious role that **worked examples** (e.g., Atkinson, Derry, Renkl, & Wortham, 2000) and **peer tutoring** (e.g., King, Staffieri, & Adelgais, 1998) can exert in learner cognition.

These four areas themes will be treated briefly and discussed in the context of a theory of personalized learning communities (Hamilton & Jago, 2010) to establish the rationale for a comprehensive approach to the research projects underlying this session. We will allude to and make reference to

- strategic planning and development of digital media to furnish alternate instructional forms, anticipate and address student misconceptions, and face important subtleties or nuance in content that are difficult to address in live classroom settings;
- finding a large space for teachers to perfect their unique and individual teaching styles while customizing instruction for their own students in environments that include or emphasize high-stakes accountability;
- forming a cumulative and living body of work that is available to students, teachers, parents, and intelligent agents in live tutoring and instructional settings;
- benefitting from the advances of lesson study in digital media and repository development; and
- fashioning new ways for students to interact with each other and with teachers in digital media.

### **Workshop Part 2: Hands-on Demonstration and Participation**

We will give a hands-on (accelerated) demonstration of how teachers and students are introduced to the media creation process. We will have several tablet computers and pen pad devices available. We will allow participants to create sample lessons or worked examples. We will furnish instructions and “non-trivial” design principles that guide teacher and peer-student-tutor development of effective, classroom-suitable media.

The intention is not simply to have participants create media, but to reflect verbally and in the group context on how the process of producing and editing content becomes an exacting exercise of mapping content to cognition. Although our research efforts are in early stages, we have already developed a sizable body of interview data in which teachers reflect deeply on the competencies that they find themselves exercising and growing during media (Hamilton & Harding, 2010). Again, the underlying project is not limited to the repositories that are produced– the outcomes more importantly include how teachers and students change and become more mathematically sophisticated and powerful in the collaborative process of producing the repositories.

### **Workshop Part 3: Simulated Lesson Study**

In the next section of the workshop, we will simulate a lesson study. This involves participating teachers and peer-student tutors seeking to understand and perfect each other's videos using the lesson study methodology brought to US audiences by researchers such as Catherine Lewis (Lewis, 2002). We will do this, if circumstances permit, with participants both locally at the conference and remotely.

### **Workshop Part 4: Reflections by Teachers and Peer-student-teachers with Audience Interaction**

The entire workshop is meant to entail open discussion and hands-on activity throughout. This segment of the workshop involves more purposeful Question and Answer (Q & A) by the audience with the peer-student-tutors, the teachers, and researchers involved in the project. The Q & A will be free-ranging depending on the audience, of course. The kinds of questions that the peer-student-tutors and teachers in the project may expect include whether or how the library creation exercise or expands creativity; how or whether it alters pedagogical concentration, precision of explanation, technological fluency, confidence in furnishing individualized instruction; whether it alters their willingness to delve deeply into student misconceptions or difficult nuances. In past study, we have found that teachers speak eloquently and surprisingly to these questions. In this workshop format, we expect CSSL attendees to challenge the assumptions and probe the experience of the teachers and peer-student-tutors.

### **Workshop Part 5: Adapting Other Simulation and Applet Content: Demonstration of Leveraging OER**

One of the most important elements of this research effort is mobilizing existing digital infrastructure. The workshop thus far has emphasized building content *de novo*. Of course, there is a large body of content applets and simulations that are freely available as open education resources. Yet these are often very difficult to use in real-time classroom settings, and may involve mismatched flash versions or other non-portable software. That is, a teacher can locate a valuable or compelling applet resource freely available online, but it might not be useful with a whole class or lend itself to adaptation to full class lesson; and it might not be readily available when a student poses a question during a class discussion or in private study. It likely requires trial-and-error parameterizing and validation. In this project, teachers and peer-teaching students do all of this in advance; they determine which parameters (e.g., values for variables, or scale of axes, etc.) most effectively highlight ideas that they want to convey, and then they can fill in values, move sliders, and use pallets etc. By capturing the teacher's running of the applet to platform-independent and mobile-enabled video, students and parents have more ready access to the underlying mathematical idea, and can see how to perform the applet if they wish to parameterize it on their own. Instruction on individual applets is time intensive and distracting in live classrooms. It just cannot happen frequently, nor is it realistic to expect otherwise. But by pre-testing, authenticating and storing an effective applet created elsewhere, teachers can make it reliably available to students.

### **Workshop Part 6: Partnership Development**

This project reflects a sort of thin-client, sharable and adaptable approach to professional development, creativity, and student involvement with teachers in mathematics teaching. It relies on and elicits teacher and peer-student-tutor creativity and ingenuity. In the final section of the workshop, we seek to build collaborative possibilities for this approach and gain insight from the audience about ways to refine and improve the underlying framework and implementation of the effort. We also seek to build partnerships with others who are interested in adopting the approach.

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## ICT for Educational Pedagogical Innovations and Learner Diversity

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**Abstract:** Technology is one of the important tools for learning and teaching nowadays. This session aims at introducing various technologies and strategies used in different schools to enhance teachers' pedagogical practices and cater learners' diversity. It includes, using an intelligent tutoring system for Special Education Needs (SEN) students, using learning management system for intellectual disability students, as well as through one to one computer and online role play games to facilitate students' learning. It is hoped that this session can give some inspirations and stimulations to education community for the implementation of e-learning that cater the learner diversity.

### Structure of the Session

This session includes four strategies for using technology to cater for learners' diversity and teachers' pedagogy nowadays in Hong Kong. The first two strategies are especially designed for students with special education needs and two are for normal primary school students.

### Intelligent Tutoring for SEN Students in Mathematics and Liberal Studies

Usually, the SEN students have tremendous difficulties in learning. They do very often lag far behind the standard of other ordinary students in the same class.

An Intelligent Tutoring System (ITS) may not be able to solve completely the problem, but to some extent may ease the situation. The aim of this project is to establish such kind of online learning platform under the sincere help from the commercial partners. The subject content will involve Mathematics and Liberal Studies.

### LMS for Assessing Students with Intellectual Disabilities in Mainstream Curriculum

The targets for this project is built on a joint university-school project on a curriculum approach that gives students with learning difficulties associated with any range and type of disabilities to access the general curriculum.

The school proposes to build a tailor-made web-based Learning, Teaching and Assessment Platform (SELTAS) that evolves from the curriculum framework and structure of the general curriculum. The proposed e-learning system of SELTAS is structured around the 8 Key Learning Areas of the general curriculum. This is different from many e-Learning platforms and applications which only focus on specific KLA. This is an important feature as it not only ensures that students with intellectual disabilities would be exposed to a broad and balanced curriculum, but that all learning elements will be organized under the same system.

SELTAS is divided into three Main Modules. They are File Management System, Learning Management System and Assessment Management System. On completion, the SELTAS will be the only teaching, learning and attainment referencing System that has been designed for students with intellectual disabilities. Teachers can freely access the system to import their lesson planning data, creating resources or downloading resources relevant to their lessons. Students can also access the system to engage in practice and exercises that have been designed to match their levels of attainment. Students with input device deficiencies can access those learning exercises based on their attainment levels, with assistance from teachers, parents or specially designed input aids. This is different from existing platform which have been designed for teachers and students of attainment levels above those of an average Primary One Student. The system is built on the framework and structure of the general curriculum ensuring that it is applicable to teachers and students in general and special schools.

### The Future School in Hong Kong

This presentation is going to show the latest e-Learning development in Hong Kong using the experience of

Fung Kai Innovative School which was one of the 12 worldwide schools in the "Innovative Schools Programs" in Feb 2007. This innovative e-Learning project aims at constructing a student-centred learning and assessment for learning with the integration of ICT in teaching and learning for the 21st century.

With the advent of technology, the school has created the technology rich environment where students can access the Internet with their own Netbooks anywhere at any time with the interactive e-Learning content of English, Mathematics and Chinese. These learning materials are co-developed by the school and the publishers. Besides the project also includes the design of an interactive platform namely "SharePoint" which allow students for uploading and downloading e-Learning materials, data-analysis discussion in groups and the forum with instant feedbacks among peers and teachers.

### **Use of Educational Games for Experiential Learning**

Genesis Era is a student-centred project, utilizing the concept of virtual online gaming, akin to major massively multiplayer online role-playing games (MMORPG) such as Dungeons and Dragons. Students can create their own character and play with others in the network in real-time interactive virtual space. The game will make it possible to chat, share the learning progress, collaborate in group and seek help from others. As a player, students can help their kingdom to complete the missions (learning tasks) which allows them to enhance the skills of their character and rewards them with golden coins they can use to buy their characters clothing and weapons from the virtual store. Virtual characters can join the missions by walking through different virtual areas, including the Royal Palace, library, home, clothing stores and furniture stores. "Genesis Era" through constant learning tasks, develops the habit of continuous learning. The game world provides different levels of learning missions to enable students to clear the missions by their choice, individual ability and aptitude. It can build up their spirit of self learning, and they can enjoy the pleasure of learning.

The project will be conducted by 2 schools: St. Edward's Catholic Primary School and Tsz Wan Shan Catholic Primary School. Both schools have rich experiences in developing school-based curriculum and will develop the new online role play games with 2 publishers and a game programming company. The hardware and the network services will be supported by a telecommunication provider.

The design of the online role play game project is based on each unit and contains a number of different abilities and levels of learning tasks with electronic text and multimedia materials. The teaching process includes several major steps, namely preparation, classroom learning activities, after-school consolidation exercises, self-classroom and outdoor learning. Before teaching at school, students have a pre-task mission at home. They will help teachers to know students' ability levels and understanding, and the potential difficulties in learning the content. Then, teachers can adjust the learning objectives and teaching strategies. Students use tablet computers with wireless networks to complete the learning missions. Teachers design some interactive learning missions to conduct the whole lesson. Students can attempt the missions with their classmates by using the platform grouping function and share their mission result with each classmate. Both teachers and classmates can give feedback for their learning immediately. Through "Genesis Era", the teachers can easily understand students' learning progress and arrange suitable after-school consolidation exercises. Students can do the consolidation missions at home after studying in the classroom. Teachers can give different levels of missions to individual students according to the performance of school learning activities.

### **Theme of the Session and Expected Outcome(s)**

Teachers from the SEN schools will share their experience on using tutoring system and learning management system for catering individual differences first and then teachers from the normal schools will provide some practical strategies how the use of ICT such as one to one computing and online game to facilitate the development of 21<sup>st</sup> century skills and cater for learners' diversity.

By the end of the session, the participants will

- understand the functions and content of the e-Learning platform in Case 1
- have thoughtful understanding of the web 2.0 functionalities in Special Education
- know more about the importance of centralization and categorization of LTA (Learning, Teaching and Assessment) resources
- have the understanding of SAME curriculum (Systematic Approach to Mainstream Education)
- be inspired to reflect what they need to prepare for the implementation of the e-Learning project in their own situations. They may consult or seek further support for planning their school based e-Learning project if they want to take a step forward for this change
- find out how virtual online games can build up students' spirit of self learning so that they can enjoy the pleasure of learning

**Session Activities—Brief Rundown of Each of the Activities to be Conducted in Sequence, with Focus, and Person(s) Involved**

	Session Activities
1	Intelligent tutoring for SEN students in Mathematics and Liberal Studies
2	LMS for assessing students with intellectual disabilities in mainstream curriculum
3	The future school in Hong Kong
4	Use of educational games for experiential learning
5	<i>Q &amp; A</i>

## Designing Visual Tools to Scaffold the Process of Learning How to Learn Together

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### Introduction

This interactive event will be presented by a group of researchers who contribute to the R&D Project Metafora - Learning to learn together: A visual language for social orchestration of educational activities - <http://www.metafora-project.org>

The project, launched in July 2010, will result by the end of its 3-year duration in the creation of a Computer-Supported Collaborative Learning (CSCL) system to facilitate 12 to 16-years-old students' planning of activities in science and mathematics. The project follows a design-based research paradigm to investigate whether and how it is possible to foster collective planning in mathematics and science classrooms. The aim of the project is that students will, first and foremost, learn to learn together addressing a "challenge" posed by the teacher involving a relatively complex science or math problem through iterations of planning the learning activities, enacting them and discussing its results, in a social constructionism context. Working in groups of 4 to 6 students during a period of 2 to 3 weeks, the students will plan, organize and engage in learning tasks, working sometimes as individuals and sometimes collaboratively.

The Metafora environment will offer a space for collaborative planning and collaborative problem solving where students will gather and discuss their plans, findings and emerge with an agreed solution, using in the process software tools to support planning, discussion, microworld for inquiry based learning, as well as other "domain tools" such as simulations.

The use of a specially-designed visual language will permit the students to communicate with one another in planning their learning and also to be precise in that planning and in enacting the planned activities. The system will also intelligently follow up the student activities and produce useful information for them and for their teacher.

### Theme of the Session and Expected Outcome

The session explores an example of the design of new tools to support learning by researchers, teachers and students working together. The context of this collaboration was the need for a set of visual tools that could support students planning complex learning together in order to become more aware of the key components of learning to learn together. During the interactive event we will present and discuss our special implementation of "design workshops" which were developed by the Metafora team for the design of the Metafora platform.

The design workshops are aimed at incorporating researchers, teachers and students in the design process from the very start. In order to have some understanding of possible learning gains that students might have and possible benefits to teachers while they are engaged with the (forthcoming) tool, there is a need to have a first approximation on how the tool will look – and what kind of benefits it might possibly support. After creating an overview of the platform (a mockup) as a first approximation we engaged teachers and students in short scenarios (1-3 hours) of "real learning activities" of solving a challenge in math or in science, providing them with preliminary means to achieve this goal with the Metafora platform. As Metafora is focused on the use of a modeling language (referred as visual language) for planning a sequence of learning activity by a group of students, we decided to focus on learning scenarios that afford such process. The expectation behind this approach is that short-term trials with teachers and students will help us develop an understanding of the key processes involved in planning activities and in learning to learn together more generally. The outcomes from these workshops support our design-based research approach and –at this stage- facilitate the design of the first prototype of the Metafora tool and particularly the development of the modeling language.

To this end we have designed an activity of collaborative planning carried out by a group of 3-5 students. The planning phase was supported by a set of special cards with visual symbols that entails different learning activities (e.g data collection, hypothesis, evaluation, experimentation using simulations and microworlds, etc.) and connectors. Both sets were presented either with paper and pencils or by using a simple visual editor on the computer. The student were asked to plan together how they are going to solve their challenge (within 2-3 weeks), by using the visual symbols. Preliminary results of the first round of our design workshops directed us to formulate our first set of research questions which tackles mainly two dimensions of theoretical framework: (1) to what extent the use of the visual language for planning scaffolds the process of

learning dialogic inquiry in Science and Math? (2) To what extent the use of the visual language for planning scaffolds the process of Learning to Learn together (L2L2)? These overarching research questions helped the team to develop more specific research questions – e.g., to what extent the use of the visual cards helps students with developing shared understanding over time, and to what extent the use of specific visual symbols supports students' understanding on key concepts of science and math. The emergent of these research questions help us with designing the next iteration of the design workshops which will in turn focus on some more specific issues such as supporting student's work with the visual symbols as well as recommendations for a better set of visuals to support expected learning gains.

In parallel to the use of the visual language in Metafora the team engages in a process that allows end-users to inform our understanding on students' and teachers' needs for awareness and visualization in the system. To this end we present the participants with possible analysis components that may accompany and support the learning process of the students and teachers with the Metafora tool. During the design workshops we present our end users with scenarios and support them in verbalising requirements that inform the development of the analysis components of the system and the various awareness and visualisation tools that can support the use of Metafora in realistic situations.

To summarize: the design workshops that are concerned with the design of the Metafora platform enable us to incorporate the valuable knowledge of teachers and students about learning, with in the actual design of our learning tool.

The expected outcome from this session is to construct a network within the research community that will focus on possible ways to involve researchers, teachers and students with the design of learning tools that promote the emergence of new and updated theories about learning through design-based research.

Eight researchers from the Metafora project will present five different aspects related to the design workshops, preceded by an introduction and followed by a discussion with teachers that participated in design workshops, who will be virtually attending the event.

Table 1: Design workshop's aspects presented in the interactive event.

Topic	Focus	Presenter
Introduction	Overview on the Metafora project and the design-workshop- incorporating students and teachers in the design process, as a part of the design based approach paradigm	Reuma De Groot and Baruch Schwarz
Theoretical background on learning with the Metafora system	Being able to learn together with others in online mediated project teams is often posited as a key 'knowledge age skills'. To teach and to learn this complex skill we isolated some key features in the form of a set of graphical icons for planning and discussing tasks together.	Rupert Wegerif & Yang Yang
Visual language and its possible use- a short demo	How can graphical models created from a visual language support the planning process and the meaning making of the students of what they are going to do? How can visual languages be designed in a multi-disciplinary and participatory process?	Andreas Harrer
Following teachers' and students' work in Metafora	How can Metafora track what students are doing to benefit both them and their teachers?	Bruce McLaren and Manolis Mavrikis
Voices from the field	Sharing key moments of learning by the group within the Metafora design workshops, using videos and transcripts.	Reuma De-Groot and Baruch Schwarz
Learning Scenarios with a microworld	Presenting learning scenarios with a microworld, and the use of a visual language	Chronis Kynigos and Manolis Mavrikis
Virtual discussion with teachers who participated in the design workshops		Reuma De-Groot coordinates

## Endnotes

- (1) The Metafora project is partially funded by the European Commission's FP7-ICT Programme under contract number 257872



## Teacher as Co-designer in Developing Technology that Supports Liberal Studies Learning

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**Abstract:** This is an educational showcase of a school –university partnership project on using web 2.0 technologies to support inquiry learning. We will provide an overview of the approach that has been taken in the design research effort and showcase of the features of the technology being developed. Then teachers will share how this emerging design practice can facilitate the learning and teaching in Liberal Studies and the challenges that they are facing.

### Description of the Project

Liberal Studies is a new mandated subject in the Hong Kong New Senior Secondary School curriculum in 2009 (EMB, 2005). This subject focuses on fostering students' lifelong learning and inquiry skills. The characteristics of this subject are different from those context based subjects. It does not have fixed content for teachers to teach. It adopts an issues-enquiry approach and the learning is structured around enquiry into a range of contemporary and perennial issues around six core themes namely "Hong Kong today", "Modern China", "Public health", "globalization" and "energy technology and environment". In addition, the assessment method in this subject is also different from other subjects. It includes students to engage in a one year independent enquiry Study (IES) and school based assessment for both process and product by using rubrics.

With these changes teachers are facing a series of challenges. Such as how to tackle the depth and the breath of the curriculum as there is no fixed curriculum content to teach. Another challenge is how to evaluate students' process learning including independent thinking, Communication and Effort as well as to keep the data systematically? To meet these challenges, teachers need some new pedagogies and assessment strategies, and as well as an online learning and assessment platform which support and manage students' learning in Liberal Studies.

The "Learning 2.0: an Online Platform and a Teacher Support Network for Curriculum and Assessment Innovation in Liberal Studies for the NSS Curriculum-" (Learning 2.0) project is a university-school partnership project. It is granted by Quality Education Fund (QEF). It includes two phases. Phase I and Phase II. Phase I (2008-2010) is to design, implement, and evaluate a Moodle-based (1) online learning and assessment platform (iLAP (2) with the URL: <http://learning20.cite.hku.hk>) for supporting enquiry learning in LS and to set up a teacher professional network for curriculum and assessment innovation. Five schools were involved in phase I. Teachers in these schools take up the role of co-designers in designing the platform. Phase II aims to integrate an e-portfolio component in the iLAP so as to support school-based assessment in Liberal studies. It also aims to scale up the teacher professional network to 10 schools and to disseminate innovative practices as well as to facilitate the collaborative culture among schools. A project website is available at <http://learn20.cite.ku.hk/phase1>.

The design of the project is guided by the following five design principles:

1. **Provide support for learning as well as assessment.** We see assessment and learning as integrated, consistent with the intent of SBA and Assessment for Learning. Hence learning tasks and scaffolding will be built into the system on important learning outcomes targeted in the LS curriculum.
2. **Provide support for the whole LS program, not just the IES.** While the IES is a major opportunity for students to learn to undertake extended enquiry, it should be seen as a culminating learning experience for enquiry and not the only enquiry related learning in LS. In fact, the other six LS modules play important roles in helping students to develop the skills and conceptual understanding necessary for good enquiry. Hence this project will provide learning and assessment support for all components of the subject for the entire duration of three years.
3. **Use of Web 2.0 technologies.** Technologies such as wikis (e.g., *Wikipedia*) are interactive, and can be used to support a range of collaborative learning activities such as peer review, shared bookmarking, communal tagging. These technologies are easily available as "open source" and can be modified to be components of an integrated and interactive system to support enquiry. By beginning from open source software, we will substantially reduce cost as compared with developing proprietary software as well as reduce the threats to the sustainability of the software. Also, it will provide an opportunity for students to be fluent with the constructive use of the latest

technologies for learning, communicating and the creation of knowledge products as an outcome of their enquiry.

4. **Teacher network for deepening and scaling up curriculum and pedagogical innovation in LS.** This project will build on our successful experience in an EDB-funded Knowledge Building Teacher Network project in CITE which is providing support for a network of teachers who are developing expertise about how to support and assess enquiry in a range of subjects at both primary and secondary levels.
5. **Development of learning technologies and digital curriculum resources as an iterative process integral to the process of pedagogical innovation.** The project will involve teachers as *key collaborators in the design process*, and will use several iterative cycles of design and evaluation to develop the support systems. This differs from existing development processes in which software is usually developed in-house and is then tested by potential users. The advantage of such an approach is 3-fold: (i) a much more user-friendly system, (ii) a system that will be amenable to further extensions by users, and most importantly, (iii) the technology platform as well as the teacher network will be a valuable “blended” (or integrated) infrastructure for the dissemination and scaling up of the innovation, hence addressing the issue of sustainability of the innovations, which is normally a most challenging one facing innovations in general.

Teachers from the ten schools come to the University every week to have regular meetings. In these meetings the project team members and teachers discuss the issues arise and share their pedagogical experiences in using iLAP as well as to work collaboratively and using design research approach to develop the curriculum. During the whole process, it requires teachers to actively engage in a cyclical process that includes planning, practicing, observing and reflecting (Elliott, 1991; Lewin, 1946) on the development of curriculum materials as well as the development and implementation of iLAP in supporting the enquiry process in LS. Through the co-design activities, lesson observations and collective discussion on the curriculum design, it is hoped that teachers’ professional network can be built up.

### Theme of the Session

The main theme of this session aims at introducing the iLAP and teachers will share their experiences in using iLAP for enhancing the learning and teaching in the LS.

First the project team will briefly introduce the iLAP and some of the conceptual frameworks guiding the development of this project as well as some hands-on exercises to show case some of the features of the iLAP.

Then teachers will share with us the following aspects:

1. How web 2.0 technologies can help students to learn LS,
2. How the notion of assessment for learning can be carried out by using the evaluation system including teacher evaluation, peer evaluation, self evaluation as well as the e-portfolio system.
3. How the iLAP and teacher network system can support the professional development as well as sustaining the innovative practices and scaling up the practices within the community.

### Expected Outcomes

It is hoped that through this CSCL in practice showcase can bring some stimulations on how those web2.0 technology can support liberal studies teachers in Hong Kong to face those new education challenges and stir up the discussion about how web2.0 technology can support the inquiry-based learning that advocated in the education community around the world.

In addition, as aforementioned the nature of liberal studies is quite different from the traditional subject, we would also like to stimulate discussion on how technology supported learning design environment can help teachers to unpack their design concepts and rationales. It is hoped that through these learning designs, the tacit knowledge in their pedagogical design can be exhibited and being as some of the resourceful materials for the teacher professional development.

### Endnotes

- (1) Moodle is an open source Learning Management System (LMS). Details can be found from <http://moodle.org/>.
- (2) iLAP stands for interactive Learning and Assessment Platform. Details can be found from <http://learn20.cite.hku.hk/page.php?page=platform>

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## Accelerating Learning to Write with Reciprocal Peer Review

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**Abstract:** The goal of this project is to join the world effort of improving writing skills in colleges and universities. With the Accelerating Writers through Technology-Scaffolded Peer Review (ACCEL) application, we aim to re-shape writing instruction with a familiar but understudied tool, peer review of writing, but in a new way that addresses typical problems associated with peer review of writing. In the demo, we will show the ACCEL system, a web-based, hybrid-intelligent, collaborative learning system supporting the form of reciprocal peer review for writing. Visitors may experience a wide range of ACCEL approaches with poster presentations, top-notch empirical studies, video clips, and actual use of the ACCEL system.

### Project Description

The goal of this project is to join the world effort of improving writing skills in colleges and universities. With the Accelerating Writers through Technology-Scaffolded Peer Review (ACCEL) application, we aim to re-shape writing instruction with a familiar but understudied tool, peer review of writing, but in a new way that addresses typical problems associated with peer review of writing.

Russell's (2002) historical review of writing instruction clearly demonstrates that improving undergraduates' writing skills has been a long-standing goal of institutions of higher education for more than a century because writing well is critical for academic and professional success. A great number of college students, however, remain at a lower level of writing ability than is expected by colleges of incoming freshmen (Kamil, 2003). Students are required to complete increasingly complex writing in college, addressing varying disciplinary expectations through the writing they do in different courses, yet they are not adequately prepared to accomplish those tasks.

To address this unfortunate Writing Crisis (Graham & Perin, 2007), and to help students develop the strategies they need to effectively address the different writing tasks they will face in college and beyond, colleges and universities in many countries commit considerable financial and pedagogical resources to offering and administering writing courses with small enrollments per section to substantial numbers of entering first year students. For example, individual universities tend to offer a few hundred sections of first year composition every year and also another hundreds of writing courses for upper level college students in subject matter disciplines.

Although students make considerable progress in these writing courses, one or two courses are not enough to address all the weaknesses that so many students have as writers. Thus, most colleges also have additional writing requirements, typically as part of writing in the disciplines. These courses develop discipline-specific writing skills. But because students are typically still struggling with more general writing problems, these courses must also contribute to general writing development. However, there is often not enough time in the curriculum (or instructor resources) to address both discipline-specific writing issues and general writing issues. Here again, peer instruction can be quite valuable. But again the value of peer review depends on peer review giving and using skills that student have develop. If those skills are strongly developed in writing courses, later peer review experiences will accelerate writing skill development.

Reciprocal peer review gives students many opportunities to improve their reading and writing skills, when they act as writer and when they act as reviewer (Charney & Schunn, 2007). For a student in the role of writer, the first round of a multiple-draft assignment begins with conducting research and writing a draft. But, after receiving comments from a peer, the writer has more to do, reading and considering the feedback and producing a revised draft. It is in these post-review activities that the student-as-writer engages more intensively in tasks related to improving his or her writing, rather than to acquiring content knowledge. In the role of reviewer, a student engages in reading, text analysis, and writing. He or she must carefully read a draft, interpret the evaluative criteria, detect and prioritize problems, make a holistic assessment, and draw on writing skills to formulate comments. Coming to understand the criteria well enough to apply them to another student's paper will have clear benefits for the student's own understanding of the assignment and improve his or her writing and revision activities. More gains are possible through a second round of review, in which the same reviewers evaluate the writers' revised drafts and receive feedback on the helpfulness of their comments. These reciprocal activities help students become more self-sufficient by strengthening their self-regulation of reading and writing activities (Nystrand, 1986; Schunk & Zimmerman, 1997; Zimmerman 2000; Zimmerman & Kitsantas, 1999, 2002; Vygotsky, 1978).

Although peer review strongly supports the development of writing skills (Beach & Friedrich, 2006; Charney & Schunn, 2007; Graham & Perin, 2007a; Hattie & Timperley, 2007; Minchew & McGrath, 2001; Shaw, 2002; Topping, 1998; Zemelman & Daniels, 1988), without a technologically advanced platform, three barriers restrict the maximal advantageous use and adoption of reciprocal peer review in writing and subject matter classes.

### **Theme of the Session and Expected Outcomes**

In the demo, we will show the ACCEL system, a web-based, hybrid-intelligent, collaborative learning system in the form of reciprocal peer review for writing. Visitors may experience a wide range of ACCEL approaches with poster presentations, top-notch empirical studies, video clips, and actual use of the ACCEL system.

The demo shows key aspects of the application in supporting writing instruction especially in large courses without sacrificing learning and instruction. The ACCEL demo will provide instructors or researchers with theoretically and empirically guided classroom writing pedagogy that actively engages students in writing and reviewing processes in a way that will help them to learn writing skills. With minimal instructor effort, the system provides more structure for developing good writing and reviewing assignments, enabling more thorough peer reviewing, and providing more accountability at the student, class, and program levels.

We expect visitors to experience how the system supports writing instruction or research for free of charge. Thus we seek international collaborations with instructors and researchers who are interested in writing instruction.

### **Session Activities**

The demo consists of three parts running in parallel: poster presentation and flyers, video demo, and visitor participation. With the poster presentation, we will describe the system architecture and its overall interfaces for students, instructors, and administrators. The video demo shows key aspects of the application, focusing on how students and instructors use the system. The other one is visitor participation. Using one of the laptops visitors are allowed to actually use the system.

### **Acknowledgement**

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Available upon request

## Automated Data Analysis to Support Teacher's Knowledge Building Practice

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**Abstract:** Incorporating asynchronous online discussions as an integral part of introducing knowledge building (KB) in the formal school curriculum poses significant challenges to teachers. Making sense of the sheer volume of students' postings and identifying appropriate facilitation strategies based on these postings is a daunting, if not impossible task even for experienced teachers. This interactive event show cases the work of two research teams that have been developing tools to address teachers' concerns and researchers' interests on students' participation and idea progression in KB discourses. The approach taken by the team comprising researchers from the Centre for Information Technology in Education (CITE), University of Hong Kong and the Center for Knowledge Engineering (CKE), Beijing Normal University is to develop a web-based discourse analysis tool that can provide various forms of participation statistics as well as automatic coding based on linguistic features. The efforts of the Quebec-based team focuses on the use of lexical analysis, using preset lists of concepts or specialized dictionaries, and visualization of latent semantic analysis results.

### Theme of the Interactive Event

Collaborative Knowledge building (KB), the production and continual improvement of ideas valuable to a community through collaborative efforts, is an important educational goal in the 21<sup>st</sup> century knowledge age. In Hong Kong, there is a history of more than ten years of implementing KB pedagogy and related online discussions in classrooms of different grade level and subjects. Although it has been well-received as one of the main educational goal of the 21<sup>st</sup> century, KB teachers find it difficult to monitor and assess students' participation and learning gain from online collaborative discussions. These difficulties arise from quantitative and qualitative approaches to assess online collaborative knowledge building discussions.

Quantitative approaches, for example participatory statistics, has long been used as a quick and easy indicator of students' participation in the online discussion. To a certain extent it is an informative indicator about students' participation in the online discourse. However, these figures do not necessarily reflect quality of idea progression among students; also, they are easily susceptible to students' manipulations in order to meet teachers' expectations. Qualitative approaches, on the other hand, impose other kind of workload to teachers. First of all, the sheer amount of postings contributed by students made reading and evaluating quality of online discussion a time consuming task. Second, the asynchronous nature of KB discussions made teachers think they have to keep constant eye on students' discussions in order to keep it on track. Although numerous in depth analysis has been conducted by researchers on various aspect of students' KB discourse, like evaluating progressive inquiry of ideas by students (e.g. Hakkarainen, 2003; Zhang et al, 2009), discourse characteristics (e.g. knowledge sharing, knowledge construction and knowledge creation by van Aalst, 2010), the theoretical underpinnings and methodology involved have been towards theory building rather than informing day-to-day teacher practice.

In order to help teachers and researchers to get timely and pedagogically relevant insights on students' KB to support teachers' day-to-day operations, research team at Centre for Information Technology in Education, University of Hong Kong (CITE, HKU) has been exploring for tools and methodologies that serve these purposes. Methodologically, the team has been investigating on understanding learner's knowledge building trajectory through visualizations of multiple automated analyses (Law, et al, 2011). In the study, visualizations generated by software tools on a number of discourse indicators, including use of scaffold supports, argumentative and questioning discourse acts, domain specific topics and associated keyword patterns, have shown to be informative in reflecting students' cognitive and metacognitive KB trajectories over a period of time. In addition, visualizations of discourse indicators also reflect the effects of teacher facilitations at various points over the KB activity.

At the technological frontier, CITE has been collaborating with the Research Center of Knowledge Engineering, Beijing Normal University (CKE, BNU) since 2006 to develop tools for the analysis of CSSL discourse data, especially discussion data in Chinese. The two parties are currently developing an online platform, COLODA – Collaborative Online Discourse Analyzer, to support analysis of online collaborative

discussion data. This platform is designed with the aim to support daily operations of KB teachers and researchers to generate timely and pedagogically relevant insights through, e.g. thread level analysis, keywords processing, automatic coding, visualization of discourse indicators and generation of relevant participatory statistics. Participants of this interactive event will be able to hands-on this analysis platform with a set of discussion data towards generating insights to inform evaluation of students' KB.

In Quebec, two paths have been taken to support feedback on students' discourse. The first is lexical analysis, using preset lists of concepts or specialized dictionaries. The second builds on the Knowledge Space Visualizer (Teplovs, 2010), and analyzes the positioning of ideas within a team or a small classroom over time. Their use in real context will be demonstrated.

## Objectives of the Session

- To introduce an automated online data analysis platform, COLODA, for teachers to gain quick and timely feedbacks about students' learning on CSCL platforms
- To explore different ways of working with online discussion forum data to gain insights to generate feedbacks for teachers' day-to-day practice

## Session Activities

1. Overview of the session.
2. A brief introduction of the tools developed by the two teams, including COLODA, the collaborative online discourse analyzer and KSV, the Knowledge Space Visualizer, highlight the analyses and indicators that these tools could provide to reveal students' progress in understanding.
3. Identifying analyses questions analysis for exploration
  - a) Participants form groups and raise questions on students' learning in the database for later hands-on analysis
  - b) Due to the time limit, groups may discuss and narrow down to 3 questions for analysis
  - c) Groups could share their 3 analyses questions to all other groups on the whiteboard for collaborations or further refinements
4. Introduction of basic operations of the online analysis platforms
  - a) Base on the questions raised by the groups, hosts of the session will introduce some basic general functions to all groups for hands-on
  - b) For more specific research questions that may require specific functions of the analysis platform, relevant functions will be introduced by the hosts in the group
5. Group hands-on session
  - a) Participants will use COLODA to generate insights to their research questions about students' learning in the database.
6. Group reports and open floor discussions

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## Design and Technologies for Supporting Collaborative Learning with Multiple Representations

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**Abstract:** The MUPEMURE in-practice showcase focuses on how learning with multiple external representations (MERs) can be promoted by technology and computer-mediated collaboration. The aim is to provide teachers (from schools and universities) and educational practitioners with guidelines for how to support learners in constructing, sharing and collaboratively reviewing MERs with the purpose of promoting learning in Science and Mathematics. One focus in this CSCL in-practice-showcase is to present, interact with and discuss the three MUPEMURE approaches—*productive failure*, *scripting* and *group awareness*—to facilitate learning with MERs in CSCL environments.

### CSCL Aspects in Practice Project and Partners Involved

In CSCL environments dedicated to science and mathematics learning, students are provided with a large array of representational opportunities that can be used in constructing, manipulating and sharing multiple external representations (MERs) of knowledge. The potential benefits of giving students the opportunity to generate and interact with MERs have long been recognized in research on MERs (e.g. Ainsworth, 2006) and in computer-supported collaborative learning (CSCL; e.g. Suthers & Hundhausen, 2003). Generating and making sense of MERs are complex tasks, however. In many cases students have to cope with difficulties related to the translation between representations, and to the use of these representations to build their own internal models. Therefore, learners typically benefit from some degree of guidance to translate between MERs. Modern technologies have opened new possibilities for supporting learning with MERs, for example, by enabling learners to interact with MERs in a dynamic fashion and by providing automatic system feedback on learners' actions. Moreover, recent web 2.0 developments, such as social networking sites, blogs, and Wikis, can be built upon to realize scenarios of collaborative learning with MERs.

Building on research on MERs and CSCL, we, the MUPEMURE (MUltiple Perspectives on MUltiple Representations; see <http://sites.google.com/site/mupemure/>) Theme Team, focus on how learning with MERs can be promoted by technology and collaboration, in short, by CSCL. We aim to provide educational practitioners with guidelines for how to support learners in constructing, sharing, and collaboratively reviewing MERs with the purpose of promoting learning in science and mathematics concepts. Specifically, the MUPEMURE focus is to develop and investigate technology-enhanced instructional approaches – in particular, productive failure, scripting, and group awareness approaches – to facilitate learning with MERs in CSCL environments.

### Partners Involved

MUPEMURE (MUltiple Perspectives on MUltiple REpresentations) is one of the few Theme Teams of young academics funded by the EU Network of Excellence STELLAR. The MUPEMURE Theme Team members are:

Dr. Daniel Bodemer, University of Tübingen, Germany,  
 Prof. Manu Kapur, National Institute of Education Singapore,  
 Prof. Gaëlle Molinari, Distance Learning University Switzerland,  
 Prof. Dr. Nikol Rummel, Ruhr-University Bochum, Germany,  
 Prof. Dr. Armin Weinberger, Saarland University, Germany.

The Theme Team is experienced in rendering MERs and CSCL research for educational practitioners and has conducted a 1<sup>st</sup> MUPEMURE workshop at the 2nd STELLARnet Alpine Rendez-Vous (La Clusaz, France, March 27th – 31st). Among the active participants of this previous workshop, who will be invited to join the proposed in-practice-showcase are Prof. Dr. Shaaron Ainsworth, University of Nottingham, England; Prof. Dr. Mireille Bétrancourt, University of Geneva, Switzerland; Prof. Dr. Gerhard Fischer, University of

Colorado, USA; Dr. Hannie Gijlers, University of Twente, The Netherlands; Prof. Dr. Sten Ludvigsen, Intermedia, Norway; and Prof. Dr. Sascha Schanze, Leibniz University Hannover, Germany.

## Theme of the Session and Expected Outcomes

### Theme of the Session

The session will focus on discussing and developing CSCL instructional approaches for facilitating students in working with multiple external representations (MERs) in different school and university learning environments. More specifically, three approaches to learning with MERs developed in the MUPEMURE project – namely, *productive failure*, *scripting* and *group awareness* approaches – will be presented to educational practitioners with the purpose of trying out and discussing how such approaches can be improved and integrated into teachers' classroom practices. In the present section, a quick overview of current educational and research issues in learning with MERs is provided, followed by a brief discussion of CSCL approaches to learning with MERs. Then, the three MUPEMURE approaches are described.

Students are increasingly confronted with MERs online that involve and combine texts, pictures, graphs, videos, etc. Additionally, more and more educational practitioners are challenging students to not only receive, but also create, link, and share MERs of knowledge with multimedia through text, picture, or video blogs and Wikis, by collecting photos and videos online (e.g., in sites such as Flickr and YouTube), or by contributing to discussion boards and social networking sites (e.g., in sites such as Facebook or MySpace). Hence, in CSCL, learners are supposed to become producers and reviewers of MERs. Especially in science and mathematics education, the rapid and continuous emergence of new information technologies provides students with a much greater array of representational opportunities (e.g., dynamic and interactive visualizations, microworlds, simulations, modeling, etc.) that can be used in constructing, manipulating and sharing representations to others. The challenge for teachers and other educational practitioners is therefore to leverage these multiple representational affordances to designing effective learning experiences for students.

Benefits of multiple representations for learning have long been observed in practice and confirmed in research. In many cases, however, students do not take advantage of MERs since they fail to translate between different representations (Ainsworth, 2006). Moreover, even though teachers explicitly design their lessons with MERs, there is often a gap between their pedagogical goals and the students' interpretations of what is expected of them when working with MERs. As Amit and Fried (2005) pointed out, students "fail to grasp the idea of multiple representations and why they are important". It is important to note that the efficacy of multiple representations does not lie in the multiple representations per se, and thus the issue for educational practitioners and instructional designers is not only how to choose the relevant forms of representation or how to design learning environments with MERs. More importantly, the instructional challenge is how to help students develop an understanding of how to work with MERs, that is, how to interpret them, translate between them, and transform them into internal representations. In such a context, researchers and practitioners need to work in a complementary way to develop appropriate methodologies and tools that assist students in developing specific competencies associated with the use of MERs, that is, multiple/multimodal representational competencies (see diSessa, 2004; Yore & Hand, 2010).

Over the last three decades, research on MERs and in particular multimedia learning research (e.g., Mayer, 2005), has largely remained focused on their role in individual learning. Moreover, the focus of research was mainly on the effects of multimedia presentation of information (presented representations), and more specifically on how verbal and pictorial information should be arranged so as to decrease (extraneous) cognitive load and therefore facilitate learning (e.g., Sweller & Chandler, 1994). Based on multimedia learning research, a series of principles were developed from which design guidelines for effective multimedia learning environments have been derived (see e.g., Mayer's cognitive theory of multimedia learning, 2005). New directions in multimedia learning are currently emerging (see e.g., the DeFT – Design, Function, Tasks – framework proposed by Ainsworth, 2006) that are based on the idea that learners do not only need to take an active part in their learning process, but that they also need to be supported through appropriate scaffolding during their interactions with MERs. For example, there are recent studies that focus on learner-generated representations (and their relations with presented representations) (Kapur & Lee, 2010) or on the role of feedback during interactions with MERs (Rau, Aleven, & Rummel, 2009).

Some CSCL studies also focus on how collaborative learners generate, share and navigate MERs. Research on CSCL with MERs is close to those new research trends in multimedia learning. In such CSCL studies (e.g., Fischer & Mandl, 2005; Suthers & Hundhausen, 2003), learners can be asked to collaborate with one another by externalizing, sharing and working with external representations (of a particular topic) that can be presented or generated by themselves (they can be also individually or collaboratively built). Moreover, a representational tool can be used either as a medium of discussion or as a way of representing discussion between students on the learning topic (e.g., Lund, Molinari, Séjourné, & Baker, 2007). All these studies show a strong influence of external representations on the way students communicate with each other and construct



shared knowledge. They also pointed out that the way representational tools are used as well as the pedagogical context in which they are placed should necessarily be chosen as a function of specific learning goals. Further work is still however needed to better understand how to facilitate learning with multiple external representations in CSCL scenarios, and also to address the potential roles of teachers in such scenarios.

The MUPEMURE project attempts to address these issues. In particular, one MUPEMURE focus is to develop and investigate technology-enhanced instructional approaches that may facilitate students to actively generate, modify, manipulate and share multiple representations in CSCL environments. We advance three contrasting designs for facilitating students. In the first design, called *productive failure*, we have students collaboratively generate representations and solution strategies to novel, complex problems without any facilitation initially, an effort that invariably leads to failure. However, this seeming failure can be productive when the support or facilitation is provided after students have worked on the task on their own. Therefore, this design delays the instructional or collaborative facilitation until after students have generated their own representations. In contrast, the second design, called *scripting*, focuses on the use of instructional guidance for collaborative groups from the beginning. The scripting approach builds on the idea that depending on learners' prior (procedural) knowledge or internal script, learners can greatly benefit from some initial guidance through an external script, that is, a socio-cognitive structure, which specifies sequences, and distributes roles and activities among learners (Kollar, Fischer & Hesse, 2006). The scripting approach orchestrates learners' activities and guides them to engage in specific sequences of roles and activities. Scripts typically include role rotation to foster equal opportunities for engaging in the relevant learning activities and help learners to consider multiple perspectives. Moreover, scripts can guide learners through different learning arrangements orchestrating individual, collaborative, and classroom learning arrangements. Script examples are the jigsaw classroom, in which learners attain expertise in specific sub-domains in expert groups and share their different expertise in their basic groups, or peer-critique-scripts that can guide learners to identify and discuss multiple perspectives on a subject. Scripts have been found an effective instructional approach, both in face-to-face collaborative learning and in CSCL for inducing specific interaction patterns and facilitating individual knowledge acquisition as well as knowledge convergence. In the third design, called *group awareness*, learners are made aware of group states and processes to foster self-regulation in groups. The awareness approach builds on technology-supported analysis of learners' knowledge or behavior, and on the idea of feeding that information back to a group of learners. Knowledge awareness approaches intend to support learners in accessing and using this information in a way that fosters meaningful learning and communication processes. For example, learners' perspectives on a subject can be gathered, transformed, and visualized in order to implicitly guide processes of social interaction that lead to an integrated view of the subject (e.g., Bodemer, 2011). These instructional approaches can be used in different learning settings such as school and university scenarios.

### Expected Outcomes

The focus of this CSCL in-practice-showcase is to present, interact with and discuss the three MUPEMURE approaches—*productive failure*, *scripting*, and *group awareness*—for supporting collaborative groups in CSCL environments to generate, share, review, and translate between MERs. Teachers (from school and also university), practitioners as well as researchers from different countries interested in such issues will be invited to interact with and contribute to the development of the toolbox of instructional CSCL approaches developed by the MUPEMURE theme team. Contacts with participants of the showcase will be maintained and a larger practice-oriented dissemination will be made through the MUPEMURE interactive website (<https://sites.google.com/site/mupemure/>). Moreover, a longer-term expected outcome would be to get funding for developing a sustainable practitioner-researcher network in which both practitioners and researchers could contribute equally to a growing toolbox for computer-supported learning with MERs.

### Session Activities

The table 1 provided below shows the sequence of activities during the 90-minute session. This session will be directed towards local as well as online users who will be able to interact by an e-voting system and to anonymously post questions and comments at any time. The online participants will also be provided with live video streams.

After a brief introduction of the MUPEMURE theme team and its main research focus, the first part of the session will be dedicated to the presentation and discussion of practice examples that illustrate the MUPEMURE work across different learning settings (school and university learning scenarios).

*Case 1* will describe the productive failure design using a hands-on activity wherein participants will be asked to estimate how small groups of students may respond to a complex problem that targets concepts they have not learnt yet. After participants have estimated (which should take about 3 minutes), actual student-generated representations will be shared. The contrast between participants'

estimation and student-generated representations will be used to anchor the discussion about how teachers can build upon and facilitate subsequent learning for their students. In doing so, the notion of and implications for what, how, and when to support collaborative groups will be derived.

*Case 2* will build upon the first case demonstrating how the instructional paradigm used there can be translated into a computer-supported setting using tabletop computers. The learning setting of both case 1 and case 2 are directed towards high school students.

*Case 3* will focus on supporting joint creation and discussion of MERs by scripting and awareness features. Here, elementary school students have been guided to first make a drawing of a science topic on a tablet, second, to compare drawings and ask critical questions to their peers, and third, compose a joint drawing. We will discuss aspects of ownership and criticism among peers as well as scripting and awareness features of intelligent drawing software.

*Case 4* will demonstrate how awareness about other students' conceptual and representational knowledge can be supported in a way that fosters meaningful collaborative learning processes. Taking the example of university students discussing statistics concepts on the basis of verbal, algebraic, and pictorial learning material, technologies and design features of group awareness tools will be discussed that can implicitly guide learning interactions.

The second part of the session will involve the audience and the MUPEMURE theme team in an interactive discussion on how the MUPEMURE toolbox can be improved and integrated into classroom learning scenarios. Jointly, we will strive to derive guidelines for computer-supported collaborative learning with MERs. Afterwards, participants will be enabled to continue such a discussion in our website (<https://sites.google.com/site/mupemure/>) so as contribute, e.g., to a growing toolbox of approaches to facilitate CSCL with MERs online.

Table 1: The MUPEMURE-in-practice session.

Session Part	Focus	Person(s) involved
1	- Presentation of the MUPEMURE theme team - Brief description of the MUPEMURE issues	Gaëlle Molinari, Daniel Bodemer, Manu Kapur, Nikol Rummel, Armin Weinberger
2	<i>Case 1</i> . A productive failure design for collaborative problem-solving with MERs	Manu Kapur
3	<i>Case 2</i> . How can children use tabletops for their drawings?	Nikol Rummel
4	<i>Case 3</i> . How can scripts and awareness tools orchestrate individual and collaborative drawing of elementary students for learning sciences?	Armin Weinberger
5	<i>Case 4</i> . How can group awareness tools facilitate collaborative learning with MERs in university contexts?	Daniel Bodemer
6	- Discussion with the audience on the MUPEMURE toolbox: How can it be used by teachers and integrated into classroom practices? How can it be developed further? - Conclusions: Audience's participation in the MUPEMURE website and also in a larger practitioner-researcher network on CSCL with MERs	Gaëlle Molinari, Daniel Bodemer, Manu Kapur, Nikol Rummel, Armin Weinberger + audience

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## **Action Research on the Effectiveness of Partnership Collaboration in ICT Language Projects**

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**Abstract:** This is a collection of cases using technology to facilitate students' language learning in English and Chinese Language in primary and secondary schools. Apart from the school partners, these cases also include some third parties such as publishers and tertiary institutions in their implementation processes. The aim of this session is to focus on the conceptual design of such framework and provide some practical strategies on the implementation strategies for the collaboration between schools and partners involved in these projects as well as to demonstrate how the e-Learning platform can facilitate students learning.

### **Structure of the Session**

This interactive session includes three cases in using technology to facilitate students' language learning. Below is the general description of the three cases.

#### **ICT in English Acquisition for the 21<sup>st</sup> Century Learners**

The project focuses on English Language Education for students in the Key Stage 3 (Secondary 1 to 2). The school sees that a 21st Century learning environment should comprise of the following 6 elements: Understanding of 21st Century Skills and Outcomes, Relevant Curriculum and Instructional Design, Informative Assessment, Authentic, Self-Directed Output, Scaffolded Content for Different Learners and Ubiquitous Access to Technology.

Based on the framework, the project will be scaffolding 4 particular topics into the existing S1/S2 English curriculum. Electronic learning content for S1 to S2 students will be jointly developed by English teachers from our school cluster (True Light Middle School of Hong Kong, Hong Kong True Light College, True Light Girls' College, Kowloon True Light Middle School) and the content provider with integration of appropriate 21st Century skills and use of technology. In addition, instructional design and assessment strategies for rigorous learning outcome will be implemented, in particular catering for learner diversity.

The learning content will be delivered through a tailor-made platform and table PCs (e.g. iPad) in a classroom setting. The ratio of student to PC is expected to be 2 : 1. The hardware platform chosen for this project is far more engaging than the traditional "point and click" input method in laptop systems, and this could transform the learning experience of students. Our project aims at changing the teaching and learning process from 1 to 40 one-way knowledge transfer model to student-centered and highly collaborative learning model. In an engaging digital environment, students can easily create, distribute and collaborate with each other.

Professional development for teachers in transforming pedagogical model are sought from consultant and a systematic professional development plan for teachers, leadership, and students will be deployed.

#### **e-Learning Resources Depository for Primary English Language**

The project schools will produce a set of English electronic learning package for P.1 to P.3 students. There are two schools participating in the project. Both of them act as testing beds to try the innovative pedagogies and e-Learning materials. Six collaborating partner organizations have been aligned to work out the implementation. They come from educational publisher, information technology sector, tertiary institution, etc. Their roles include curriculum design, WiFi system support, hardware installation and project evaluation.

The schools hope that through such high-quality package, the schools can promote a 'Paradigm Shift' in learning and teaching in terms of the interactivity in pedagogical practices and students' self-directed learning so as to enhance the effectiveness of learning and teaching. The schools believe that such 'Paradigm Shift' can help develop the idea of life-long learning.

The electronic courseware includes the core curriculum at Key Stage 1 as suggested by the EDB. To cater for individual learning differences, there will be different levels of exercises provided to students. The assessments will have 'Safety Net' so that students with learning difficulties will be able to achieve their basic competence through repeated practice and revisions. It is expected that after using the electronic courseware,

students' learning motivation and interest will be enhanced tremendously.

### **Adaptive LMS for Chinese Language Learning**

In this presentation, teachers from an e-Learning Pilot Scheme (Scheme) supported by the local education authority, the Education Bureau (EDB), will introduce how a web-based platform facilitates the learning of Chinese Language in Hong Kong primary schools. Two local primary schools with different demographic background joined hand together under the Scheme to develop an e-Learning environment in which Chinese Literacy (reading, writing, speaking and listening) is expected to be learnt through innovative ways and adaptive use of information communication technology (ICT) in the 3-year project period. By collaboration with local ICT educational service provider (ESP) and academics of the discipline from the university, such a Chinese e-Learning platform has been being developed and reviewed in terms of its applicability and effectiveness. The frontline teachers design the curriculum contents and related assessments, which will be in turn transformed into e-Learning materials by the ESP for students to be used inside and outside the classroom. The pedagogical application and adaptive use of these materials become the focus of study in the Scheme.

The present paper addressed the key features and development of the web-based platform. The new ways of Chinese Language learning will be discussed and compared with the conventional ones. With the guidance and research expertise provided by the academics, the effectiveness of the project will be discussed in the light of relevant literatures and research methodology. The expected outcomes of the project: (1) enhanced quality in Chinese Language learning; (2) student self-directed learning; (3) catering for individual difference; and (4) cross-subject integrated learning and joint-school collaborative projects/tasks (e.g., quality circle on Chinese Writing), as well as its implications to school-based e-Learning development will be discussed with reference to the observation and evaluation of the application of such a newly-developed e-Learning environment during the first stage (6-month period) of the project. The collaboration modes among frontline teachers, academics and ESP for the development of such a new e-Learning platform are to be explored and reviewed for not only the sake of efficient running (in the latter 2-year period) of the project, but also of the effective learning through electronic ways and collaborations beyond school boundary.

### **Theme of the Session and Expected Outcome(s)**

Teachers and principals from both primary and secondary schools will highlight the essence of components in designing such e-Learning materials for facilitating students' language learning as well as those implementation strategies that work with the collaborative partners.

By the end of the session, the participants will

- understand the conceptual framework, idea, implementation strategies of the project with focus on collaboration between the schools and the partners involved
- understand how the Chinese pedagogical practices is transformed into an "adaptive" e-Learning platform
- know more about the collaborative modes among teachers and across schools and service providers for the development of web-based teaching materials
- get the ideas how diversified learning needs would be catered and how self-directed learning habits would be established by means of the e-Learning platform

## Session Activities—Brief Rundown of Each of the Activities to be Conducted in Sequence, with Focus, and Person(s) Involved

	Session Activities
1	<p><i>Case 1 Presentation</i></p> <p><i>ICT in English acquisition for the 21<sup>st</sup> Century learners</i></p> <ul style="list-style-type: none"> <li>• <i>Project Scope</i></li> <li>• <i>Conceptual Framework of Project Design</i></li> <li>• <i>Aims and Objectives</i></li> <li>• <i>Implementation Details</i></li> <li>• <i>Project Timeline and Evaluation</i></li> </ul>
2	<p><i>Case 2 Presentation</i></p> <p><i>e-Learning resources depository for Primary English Language</i></p> <ul style="list-style-type: none"> <li>• <i>Vision of the project</i></li> <li>• <i>Aims of the project</i></li> <li>• <i>Ways of Implementation</i></li> </ul>
3	<p><i>Case 3 Presentation</i></p> <p><i>Adaptive LMS for Chinese Language learning</i></p> <ul style="list-style-type: none"> <li>• <i>Demonstration of an "adaptive" Chinese e-Learning platform</i></li> <li>• <i>Introduction of students' performance/work/attitude as a result of the platform (preliminary findings)</i></li> <li>• <i>Comparison of the (expected) differences in learning and teaching by means of e-Learning and conventional textbook</i></li> </ul>
4	<i>Q &amp; A</i>

## Knowledge Building International Project: Designs for Deep Understanding

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**Abstract.** Deep understanding and knowledge creation are two of the three ICT competency standards for teachers identified by UNESCO (2009). In the classroom, knowledge creation bears many similarities with knowledge building, the framework put forward by Bereiter and Scardamalia (1993). We report on four knowledge building oriented university-school partnerships (Catalunya, Hong Kong, Quebec and Mexico). They had teacher professional development in mind, and their shared goal was students' understanding of sustainable development problems (Knowledge Building International Project, 2007-2011). Participants engaged in onsite/online written and verbal interaction. The dynamics of their collaboration are uncovered. With respect to one site, we report on explanation quality as evidence of movement toward deep understanding.

### Background

The principle of deep understanding is central in contemporary learning sciences, and teacher educators (Putnam & Borko, 2000) have been taking notice. Knowledge creation (Bereiter, 2002) is also part of the educational conversation. UNESCO called on teachers to engage into knowledge creation and engage learners into this process in its ICT competency standards for teachers (2009). Van Aalst (2009) sums up the thinking of Paavola, Lipponen and Hakkarainen (2004) on knowledge creation by describing it “as a set of social practices that advance the state of knowledge within a community over time”, p. 260). Knowledge creation and knowledge building are terms that can be used alternatively in the classroom. Scardamalia and Bereiter (2003) refer to knowledge building as “the production and continual improvement of ideas of value to a community through collaborative inquiry” (p. 1371).

University-school partnerships have been recognized as a key strategy for innovation to occur within an education system (Holmes Group, 1990; Laferrière & collaborators, 2010). Collaborative digital platforms support and stretch such effort beyond time and space limits but adoption is slow. The Knowledge-building International Project (KBIP) provided an opportunity for teachers 1) to engage school learners into collaborative inquiries on sustainable development applying the Knowledge Forum platform; 2) to seek the emergence of classroom-based knowledge-building communities; and 3) to foster deep understanding of problems. In this paper, we present the dynamics of collaboration that unfolded and deep understanding is researched at one site through an analysis of question posing and explanation levels.

### Theoretical Framework

The knowledge building perspective focuses on developing classrooms and communities for progressive problem solving and knowledge creation. Scardamalia and Bereiter's (2003) twelve knowledge building principles are the following ones: *democratizing knowledge, community knowledge/collective responsibility, real ideas/authentic problems, improvable ideas, idea diversity, epistemic agency, constructive use of authoritative sources, knowledge building discourse, rise above, symmetric knowledge advance, pervasive knowledge building, embedded, concurrent, transformative assessment*. Therefore, a class of students is meant to become a community that shares a commitment to creative work on ideas and advancement of the state of knowledge in their (networked) classroom. When students engage in collective inquiry, the process is mediated by discourse on Knowledge Forum (Scardamalia & Bereiter, 2006). Knowledge Forum includes a web-based collaborative platform for extending and deepening classroom discourse, which affords scaffolds to support written discourse, and a set of analytical measures that participants and classroom-based communities can apply to monitor their own knowledge building activity.

Deep understanding is the end goal (Bereiter, 2002). Classroom-based knowledge building communities tend to meet/exceed their mandated curricula (Scardamalia, Bereiter & Lamon, 1994; van Aalst & Chan, 2007).

### Methodology

University-school partnerships have been at the basis of this innovation. In three out of four the local government also have played an important role. In Hong Kong, advances have been made in developing knowledge building pedagogy in schools. In particular, a community of knowledge building teachers (the knowledge building teacher network) has developed a model of professional development support for scaling up curriculum and assessment innovation in schools, and in establishing sustained collaborative inquiry among the international network of knowledge building classrooms. In Catalonia, the International Office of the Ministry of Education has exercised leadership in Europe regarding classroom activities that foster knowledge creation as an ongoing activity of school learners' experience. In the Americas, an increasing number of classrooms are networked through Web-based tools, thus creating new affordances for teachers and learners as they access online resources, including peers from other classrooms with whom to engage in collaborative inquiry.

## Design Research

The knowledge building international project (KBIP) is an outgrowth of the Knowledge Society Network (KSN, <http://www.ikit.org/ksn.html>). The idea was born during the Knowledge Building Summer Institute 2007, the annual face-to-face meeting of the KSN members. The summer institutes that followed were critical for renewing the commitment toward the project, identify gains, make adjustments, and plan next iterations. Changes were made to the local/international socio-technical designs on the basis of emerging results. They primarily regarded the teaching of the knowledge building principles (timing, and feedback to teachers), the matching of classrooms, and the management of databases.

## Participants

Participation may be considered an early result of design research. Over the past five years, here is an overview of the distribution of participants.

Table 1: KBIP participants.

Sites	Students	Teachers	School principals	Ministry personnel	Graduate students	University researchers
Catalonia	525	22	11	3	1	2
Hong Kong	350	13	2	1	4	3
Quebec	350	20	4	1	4	3
Puebla	150	5	2	-	-	2

## Intervention

Socio-technical designs at each site were context-based but the three following features characterized each site:

- **Principle-based innovation.** The 12 knowledge building principles guided the design of the classroom-based knowledge building communities. University-based teacher educators and researchers were instrumental in acquainting teachers with knowledge building and scaffolding their understanding of this approach (Chan, Law, Hui, Fung, & KBTN Team, forthcoming; Laferriere & Breuleux, forthcoming).
- **Computer-supported innovation.** Knowledge forum supported written discourse for all participants. At first, teachers and learners worked on their own server. Next, they were to access their partner classroom's database. In complement, a web-based videoconferencing system (VIA) provided support for audio-visual exchanges. Classrooms prepared Powerpoint presentations in a pdf format and, in best cases, they showcased what they had written on their Knowledge Forum database.
- **Team-mediated innovation.** Each partnership designated a coordination team. Coordinators were teacher educators, teachers, seconded teachers, and graduate students. At the substantive level, it was a matter of reaching consensus regarding the "umbrella theme" to be inquired into each school year, and matching classrooms with similar inquiry questions. At the organizational level, it meant numerous written and verbal interactions to establish a calendar, provide access to and guidance into databases, schedule and facilitate synchronous meetings.

## Research

Meso and micro dimensions were explored. At the meso level, ethnographic notes of videoconference meetings were analyzed by two researchers using complexity adaptive system theory (e.g., Lemky & Sabelli, 2008) for the identification of emerging dynamics of collaboration. At the micro level, the proximal conditions that led to productive online discourse were studied using ethnographic notes and the Knowledge Forum analytical tools. Moreover, the online discourse of 25 classrooms was analyzed to explore the depth of understanding students



reached at one site. The scheme was an adaptation of Lee, Chan, & van Aalst's (2006) scheme and of Hakkarainen's (2003) scheme. 251 K-6 students (289 with control group) were part of this specific study, and pre- and post-activity interviews were conducted.

## Results

### Meso-level Results

The dynamics of collaboration that stood out regard partnerships, teacher participation, and coordination.

#### Partnerships were the Drivers of Innovation

Within each partnership, teacher agency and knowledge was critical for engaging students in collaborative inquiry within and beyond the classroom. School principals were key regarding informing and getting permission from parents, and coordinating activity between schools from the same school district and beyond. Some Catalonia and Hong Kong' school principals modeled collaborative inquiries with students. Local experts (e.g., ecologists) also played an important role in moving collaborative inquiries beyond clichés and laypersons' concerns regarding the environment. University researchers' attention to teachers' concerns and analyses regarding how the knowledge building perspective was part of the school learner's experience was also critical. In Catalonia, the International Office of the Department of Education was the key agent in the partnership fostering knowledge building in a local network of thirteen schools and the participation of six of them within KBIP. The government created opportunities for innovation: teacher professional development workshops, access to curriculum experts to help teachers see links between KBIP and the curriculum (<http://www.xtec.cat/ofinternacional/COMconeixer/cat/index.html>). An association of teachers is now assuring the sustainability of the effort (<http://kbinaction.com>). In Quebec (<http://kbip.fse.ulaval.ca>) and Hong Kong (<http://kbtn.cite.hku.hk/kbip.php>) governmental agents were well-aware of the knowledge building perspective adopted, and consented extensive financial resources over a number of years. In Mexico the government was not a partner but the head of the Universidad Iberoamericana Puebla (<http://www.iberopuebla.edu.mx>) was the leading agent and financial resource. In the fifth year, a new generation of university-school partnership was the result of presentations made at a main teacher educator conference.

#### Teacher Participation Exhibited Both Flux and Sustainability

Teacher participation was in a state of flux given teacher mobility within their school system, and the growing attraction of the network. The network found coherence through 1) reference to the same twelve knowledge building principles, 2) the use of the Knowledge Forum® software, and 3) the use of the multi-user web-based videoconferencing system (VIA) for oral synchronous discourse supported by digital artefacts. Participants' core included 10-12 teachers. Some of them had their classrooms collaborate with one another while others worked with incoming teachers who for the first time engaged their classrooms in collaborative inquiries.

#### Coordination Required Diligence

For collaboration to occur within and across sites, time scheduling of synchronous events, time management, and administrative support for accessing another classroom's database were ongoing activities. For elementary teachers it was easier to schedule inquiry time than for secondary school teachers. A few did it for an hour on a daily basis over a certain period of time, some devoted a few intensive weeks, and others gave students minimal amounts of time. Secondary school teachers from Hong Kong tended to have students work after class. Both elementary and secondary teachers from Catalonia had their students stay after school to allow for synchronous verbal conversations (videoconferences) with North American students. At the international level hundreds of email messages were exchanged and Google docs developed to coordinate classrooms' online meetings.

### Micro-level Results

The proximal conditions that led to productive online discourse pertained to student engagement and knowledge building practice. Deep understanding was the ultimate goal, and we provide partial results (one site only).

#### Student Engagement was Grounded in Authentic Questioning

The dominant theme, sustainable development, provided plenty of possibilities for emerging knowledge building communities to focus on specific questions of collective interest. Question posing and explanation are pivotal to collaborative intellectual inquiry. Although much progress has been given to examining questioning and explanation in computer-based discourse (Hakkarainen & Sintonen, 2002), relatively less is known about how children collectively pose productive questions and how they sustain inquiry and advance knowledge creation in diverse and distant communities. Videoconferences among distant communities led to question posing that prompted interactions and explanations, thus providing scaffolds for children to build on others' ideas. Early

results showed that teachers and students engaged in authentic question posing, and demonstrated *epistemic agency*, *idea improvement* and *embedded assessment* (Laferrière, Law & Montané, 2010).

### Knowledge Building Practice Reflected a Critical Mass of Innovative Pedagogies

Teachers engaged in curricular and pedagogical design in a way as to demonstrate collective knowledge building among their own local/international communities. However, the release of collective agency to students for knowledge creation purposes may take many forms. The same is true regarding the scaffolding of collective cognitive responsibility in asking questions and formulating explanations. A critical mass of knowledge building practices, including translated documentation, was created onsite/online. There are now materials to showcase design research in computer-supported collaborative learning involving field-based educators and/or strong university-school partnerships.

### **Deep Understanding**

Cognitive and conversational analyses conducted by Turcotte, Hamel and Laferrière (2011) revealed that students who wrote better explanations on the Knowledge Forum scored higher on post-activity interviews even when they scored lower on the pre-activity interviews. Active use (1 hour a day) produced the greatest improvement of student explanation skills, and that confirmed teachers' impression and field observations.

### **Discussion**

The relevance of an international network grounded in university-school partnerships and devoted to an innovative theoretical framework and related pedagogies that take advantage of web-based tools is confirmed. The literature on partnerships emphasizes the importance of converging visions and strategies (Legters, Balfanz & McPartland, 2002; Bringle & Hatcher, 2002). We suggest that a partnership's solid foundation depends on a big idea, one capable of driving the agency of participants in a converging manner. Knowledge building is such an idea.

A growing number of teachers manifest interest in knowledge building/knowledge creation. Their participation in KBIP may remain peripheral for some time but it affords them an opportunity to design their own classroom as a knowledge building community. The KBIP community also provides support, be it technological or pedagogical.

Such a project requires extensive coordination. The use of different databases added to the complexity of coordination in the first four iterations of the project. For the next iteration, participants seem to be willing to access the same database. This will offer new affordances but will bring its share of design issues.

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## Supporting Innovative Teaching and Responding to Change with an Intelligent Collaborative Design Environment

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**Abstract:** This workshop explores the potential of a Learning Design Support Environment (LDSE) software application under development to support teachers in planning, designing, resourcing, and reflecting on the design of learning activities for their students. Our investigation centers on how to support teachers who wish to develop their design skills and knowledge in order to benefit from the creative possibilities opened up by digital technologies. The LDSE software is underpinned by: i) a theoretically-informed model of learning (the Conversational Framework), ii) by our empirical work with teaching practitioners, and iii) by other research in learning design. In the workshop the participants will be given the opportunity to experience hands-on the way in which the LDSE, through its AI and community based support mechanisms, can aid them in three key areas of learning design practice: i) locating and adopting, iii) adapting and repurposing, and, ii) evaluating a hypothetical learning design.

### Ideas to be Explored

A core principle of the project is “building on the work of others”, that is, making it easier for teachers to draw inspiration from, or repurpose, existing innovative learning designs and learning patterns. The LDSE software aids teachers in doing this by analyzing their learning designs, producing visual representations of the pedagogic outcomes of teachers’ design decisions, and proposing design alternatives. The conceptual framework supporting our approach is that of learning design as computer-supported collaborative learning (CSCL) for teachers (Laurillard and Masterman 2009).

### Intended Outcomes

Participants will:

- Gain experience of, and contribute to, our evolving conceptualisation of CSCL for teachers;
- Deepen their awareness of the complexity of designing for students' learning;
- Gain greater understanding of the effect of the teaching-delivery modality on the pedagogy of learning design;
- Gain insights into the potential role of an AI-based system in promoting greater rigour and precision in the articulation of educational concepts.

Interested participants will be welcome to contribute to the project further: e.g. by taking part in later evaluations.

### Session Activities

This is a hands-on workshop. Participants will be able to use the software on their own laptops and to explore how the software can support pedagogic design. This will consist of the following activities:

1. Introduction to the LDSE and familiarising the participants with the example learning design used in the workshop;
2. Participants in groups of 2-3 are asked to repurpose the example learning design to satisfy the change in circumstance (brought on by policy change) and to maximise the design’s overall pedagogical potential;
3. The groups produce initial evaluation, exchange their designs with one other group and evaluate each other designs; and
4. Plenary

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## School Network for Enhancing Student Information Literacy across the Curriculum

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**Abstract:** Information literacy is one of the important skills as required in 21<sup>st</sup> century. In 2005 an information literacy standard for students was released by Hong Kong Government (EMB, 2005). In this year the EDB launched the e-Learning pilot scheme and announced 21 school projects were selected. The implementation of the scheme will be spread across three academic school years from September 2011 to 2014. The goal of this session is to provide an overview of one of the selected project namely “The newfangled orbit of electronic learning – developing a conjoint network of information literacy” and show cases on how to integrate information literacy into various subject disciplines including English, Mathematics, Chinese Language and General Studies. Via the vivid examples, it is hoped that participants can understand how to uplift students’ technique and aptitude in handling information through diversified learning tasks and understand the development of a coherent strategy to integrate pedagogy and assessment design in various subject disciplines to enhance student’s Information Literacy skills.

### Introduction

The project is co-developed by two Primary schools, Po Leung Kuk Chee Jing Yin Primary School and Xianggang Putonghua Yanxishe Primary School of Science and Creativity, with the union of four satellite schools including Po Leung Kuk Riverain Primary School, S.K.H. Kei Fook Primary School, Lei Muk Shue Catholic Primary School and Y.L. Long Ping Estate Tung Koon Primary School in Hong Kong. Moreover, numerous parties are invited to engage in the project, such as Pui Ching Middle School Macau (Primary section) for cross-border exchange, a local tertiary institute for technical consultancy, a publishing company for teaching software, two IT companies for professional sharing and networking devices as well as a consultant from a tertiary institute for academic theories. All these parties originate a professional collaborative community to evolve subject-based electronic learning platforms, teaching resources, students’ portfolios and assessment systems, by upholding the framework of information literacy as the core nucleus. Through interactions and support provided by the above-mentioned parties, a significant and influential conjoint teaching network is incubated for sharing and publishing latest teaching resources and the fruitful result of the project.

### The Conceptual Framework of the Project

The Centre for Information Technology in Education, University of Hong Kong (CITE) (2009), defines information literacy as eight focal dimensions. They are “define, access, manage, integrate, create, communicate, evaluate, ethical use”. These eight dimensions are directly correlated to the nine generic skills, pinpointed by the Hong Kong Curriculum Development Council (CDC 2001), which includes collaboration skills, communication skills, creativity, critical thinking skills, information technology skills, numeric skills, problem solving skills, self-management skills and study skills. Figure 1 indicates the overall conceptual framework for the implementation of IL and the lineage of the nine generic skills as proposed by CDC in various subject disciplines. Through this innovative scaffold and relating the eight dimensions of information literacy to the generic skills, it undoubtedly fosters students to well-equip their learning abilities in the new century.

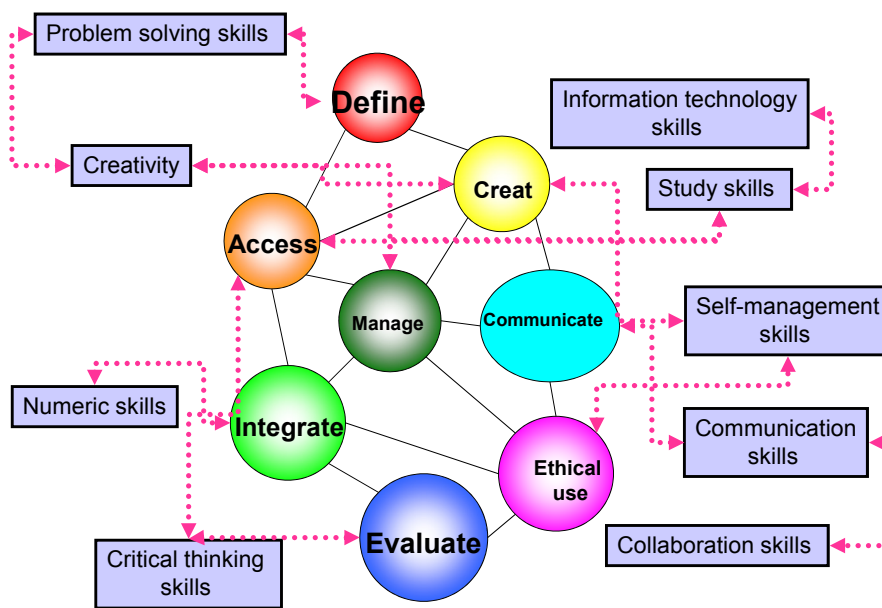


Figure 1. Overall Conceptual Framework for the Project.

This three-year project is primarily focused on the primary curriculum of P.4-P.6, in which two mentor schools and four satellite schools are amalgamated to design English, Mathematics, Chinese Language and General Studies pedagogies infused with information literacy elements collaboratively. It is strongly believed that building up this professional learning network community would help teachers’ professional growth and those developed curriculum materials will be beneficial to the education community. In addition, with the provision of tertiary institute’s professional expertise, we are making an effort to outline the framework of an information literacy curriculum and appropriate assessment criteria. As a result, the practices surfaced can then be referenced by the academic circle.

**Theme of the Session and Expected Outcome(s)**

This CSCL practice event is to introduce this e-Learning project to the audiences and share the learning experiences in the implementation processes.

By the end of the session, the participants will

- understand how to integrate information literacy elements into English and Mathematics teaching practices and pedagogies. By means of it, they can encounter how to uplift students’ technique and aptitude in handling information through diversified learning tasks
- understand the development of a coherent strategy to integrate pedagogy and assessment design in Chinese Language and General Studies to enhance student’s Information Literacy skills

**Session Activities—Brief Rundown of Each of the Activities to be Conducted in Sequence, with Focus, and Person(s) Involved**

	Session Activities
1	<i>Introduction of the project</i>
2	<i>What &amp; how the school does in electronic learning in English and Mathematics</i>
3	<i>Adoption of Information Literacy in Chinese Language &amp; General Studies</i>
4	<i>Q &amp; A</i>

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## Part 4



# Pre-conference events: Tutorials

## SimScientists: Using Science Simulations to Promote Model-based Learning and Assessment

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**Abstract:** How can we teach and assess the core knowledge and skills that students need to succeed in the 21st century? The proposed session will engage participants in the computer-based supplementary curriculum-embedded and assessment modules developed in a set of research and development projects in WestEd's SimScientists program, funded by the U.S. National Science Foundation (NSF) and Department of Education ([www.simsScientists.org](http://www.simsScientists.org)). The projects are led by Edys Quellmalz, Director of Technology Enhanced Assessment and Learning Systems in the Science Technology Engineering and Mathematics program at WestEd. Collaborators include the American Association for the Advancement of Science (AAAS) and the Center for Research and Evaluation of Students and Standards (CRESST) at UCLA.

### Theory and Research Base

Throughout a series of international and national reports and standards-setting efforts runs the theme that science education must go beyond basic science facts to support science learning that results in deep, connected understanding of science systems and an ability to engage in the inquiry practices of science (Bransford et al., 2000; Duschl et al., 2007). This recognition of the need to explicitly integrate fragmented science concepts into understanding science as systems and model-based reasoning about them requires a significant restructuring of science education. Taking advantage of the power of technology to represent dynamic models of science systems in curriculum and assessment could well transform 21<sup>st</sup> century science education.

Our approach is grounded in the profound changes simulations have made in the nature of inquiry in mathematics and science—for scientists, as well as for students (Quellmalz & Pellegrino, 2009). Simulations can represent dynamic science systems “in action,” making invisible phenomena visible. Simulations allow representation and manipulation of the causal, temporal, and spatial relationships of science systems that are too big, too small, too fast, too slow, or too dangerous for classrooms. Simulations can make these dynamic models available for extended and active investigations of authentic problems (Gobert & Clement, 1999). This allows students to develop their abilities to engage in the active inquiry practices of science. When coupled with a technical infrastructure that captures and analyzes students' actions and answers, simulations can provide rich, immediate, customized feedback for students and diagnostic reports for teachers with guidance for further instruction.

The SimScientists modules are intended to activate and reorganize the typically inert body of science knowledge transmitted by textbooks into principled models of the particular science system that students can transfer and apply to the range of examples of the system in the natural world. The simulation environment, instructional activities, and assessment tasks are organized into three cross-cutting model levels of a science system—components and functions, interactions among components, and emergent system behaviors (2000; Chi, et al., 1991; Buckley, et al. 2010). The simulation-based curriculum supplements and assessments promote and monitor students' progress in the use of the inquiry practices of science as the students create and use models to describe and investigate the science systems.

The session will engage participants in the simulation-based assessments and instructional modules developed for ecosystems units taught in middle school. Below we describe the projects within the SimScientists program from which the simulation-based assessments and instructional modules for ecosystems will be drawn and the collaborative features within them.

The *Calipers II: Using Simulations to Assess Complex Science Learning* project, funded by the U.S. National Science Foundation, is currently in the fourth year of using evidence-centered design to develop suites of formative assessments to embed in extant curriculum units, as well as unit benchmark assessments to document student proficiency levels. The assessments are aligned with national middle school science standards for six science systems, two each for life, physical and earth science. The assessment suites are composed of two or three embedded formative assessments that the teacher inserts into a unit at key points and a summative benchmark assessment at the end of the unit. The SimScientists Learning Management System (LMS) was developed to deliver the Calipers II assessments and collect data. The LMS enables teachers to assign assessments, view progress reports, assign differentiated follow-up classroom reflection activities, score constructed responses from the benchmark assessment, and view summative proficiency reports. Figure 1 presents screenshots of Calipers II embedded assessments that provide immediate feedback and coaching as students working in teams of two interact with the simulations.

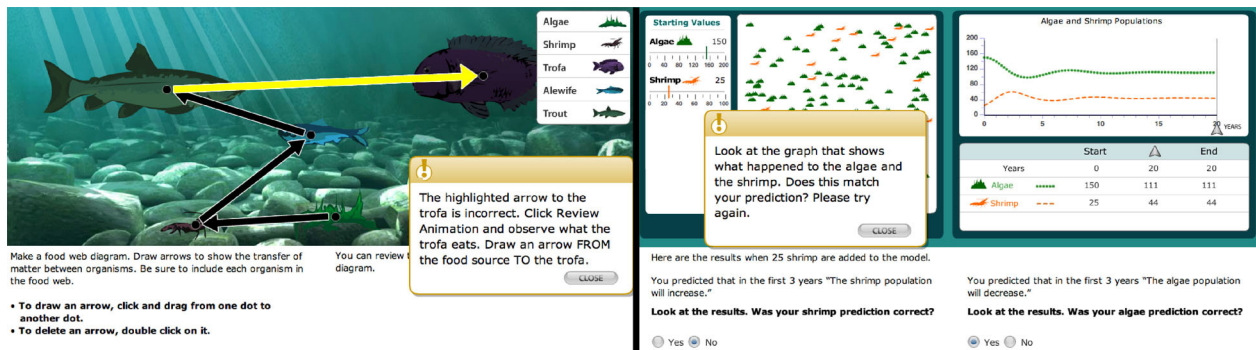


Figure 1. Calipers II Embedded Assessments Provide Feedback and Coaching.

In the left screenshot, students are asked to draw a food web showing the transfer of matter and energy between organisms based on prior observations made of feeding behaviors in the novel ecosystem. When a student draws an incorrect arrow, a feedback box coaches students to observe again by reviewing the animation and to draw the arrow from the food source to the consumer. Feedback also addresses common misconceptions. In addition, students working in teams engage in scientific discourse by discussing the tasks and questions and agreeing upon strategies for conducting the investigations and interpreting the results. The right screen shot shows feedback and coaching for investigations of population changes. The embedded assessments produce progress reports for students and teachers (Figure 2). The progress reports help the teacher adjust instruction during subsequent reflection activities that stress the big idea that all ecosystems share the same organizational structure and that similar behavior emerges from this structure. An important component of the dynamic embedded assessment is an offline reflection activity designed to provide differentiated tasks and to engage students in scientific discourse and collaboration as they apply their science content knowledge and inquiry skills to new, more complex ecosystems (Tundra, Galapagos, and Savanna). Students are assigned to teams which are given tasks that address the content and inquiry targets with which the teams needed the most help. For example, one Tundra team might examine pictures of organisms eating behaviors to agree on their roles as consumers. Another Tundra team might be responsible for identifying the producers. A third Tundra team might be responsible for beginning to draw some of the arrows depicting the flow of energy and matter in the system. Using a “jigsaw” structure, small groups merge into a larger Tundra group to combine their classifications of organisms and roles and complete drawing the food web on a poster representing the flow of matter and energy throughout their particular ecosystem. Student peer assessment is promoted as the students as well as teachers evaluate the posters and presentations of them using criteria for judging the clarity, accuracy, and evidence cited for identifying the roles of the organisms and the arrows representing the flow of matter and energy.

At the end of the unit, the teacher administers the summative unit benchmark assessment with tasks and items parallel to those in the embedded assessments, but that require transfer to a different ecosystem and do not provide coaching. Students must take the benchmark assessment individually since it is a summative assessment to gauge their proficiency at the end of the unit, whereas the teacher may assign students to work in teams during the embedded assessments. After teachers score the constructed text responses, benchmark assessment results are reported by the LMS for four proficiency levels for each target. Figure 2 shows the embedded assessment progress report and the benchmark assessment proficiency reports.

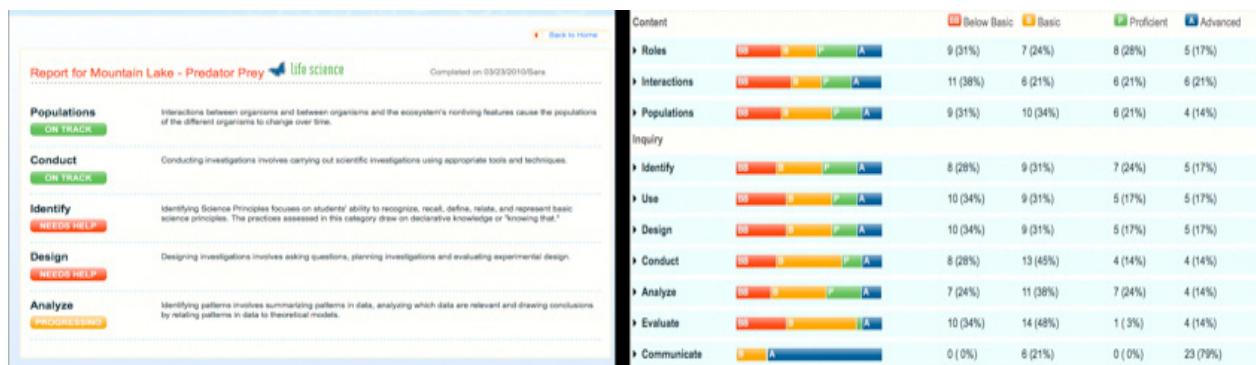


Figure 2. SimScientists Reports for Embedded and Benchmark Assessments.

The Calipers II embedded and benchmark assessments were studied in a large pilot test in three U.S. states (Nevada, Utah, North Carolina), involving 28 districts, 40 schools, and 55 middle school teachers. The resulting rich data set of 5,800 students provided strong evidence to support the feasibility, instructional utility,

and technical quality of the assessments. Teacher and student responses to the simulation-based assessments were strongly positive. The study showed that the simulation-based embedded and benchmark assessments can be used on a large scale with diverse student populations and in school systems with varying technical infrastructures. The embedded assessment coaching strategies and reflection activities provided a basis for extending these strategies into simulation-based instruction.

The project, *SimScientists: Interactive Simulation-based Learning Environments*, funded by the U.S. Department of Education is reframing the embedded assessment simulations to add enriched instruction. The project uses the Calipers II model-based learning framework and evidence-centered design principles to organize content and inquiry targets into three model levels for the instructional modules. Both instruction and assessments target content and inquiry skills at the three model levels (components, interactions, and emergent behavior). The curriculum suites feature meaningful problems, active investigations, scaffolding, reflection activities, and transparently embedded formative assessment tasks, followed by administration of Calipers II-developed summative benchmark assessments of documented technical quality. With dynamic presentations of the science system “in action” at different levels, each of the three curriculum suites overviews the levels of the system to be investigated in the upcoming simulation activities and provides explanations and examples prior to the simulation-based inquiry tasks, which use feedback and coaching like that in the Calipers II embedded assessments. Affordances of the technology, such as highlighting, zooming, and drawing arrows focus students on relevant components and processes. Culminating reflection activities engage students in scientific discourse as they collaborate to transfer their understanding of the ecosystem model levels to new environments such as the Tundra, Galapagos, or Savanna.

Each SimScientists curriculum suite consists of a dynamic introduction to the system and three simulation-based instructional modules that include instructional inquiry activities for student teams, seamlessly embedded formative assessments that capture student responses, graduated feedback and coaching, and a follow-up collaborative reflection activity to promote scientific discourse and transfer. The linked unit benchmark assessment includes similar simulation-based tasks, but without feedback and coaching. Each instructional module is designed to be inserted by the teacher into an ongoing unit on the topic. For example, after students had studied descriptions of producers, consumers, and decomposers in a middle school unit on ecosystems, a teacher could insert a simulation-based instructional module in which students make observations in a novel ecosystem to identify the roles of organisms and their place in food webs (components, roles, and interactions). Later in the unit, simulation-based curriculum modules can be inserted to investigate population dynamics (emergent system behavior).

### Theme of the Session and Expected Outcome(s)

The theme of the session is how science simulations can fundamentally transform science teaching and testing. Participants will learn how a science systems model can be used to promote learning, transfer, and principled, deep assessment. Participants will learn about the forms of student collaboration incorporated in the designs of the instructional and assessment tasks.

### Session Activities

Edys Quellmalz, Facilitator  
Barbara Buckley, Facilitator

- Demonstration of the instructional and assessment modules
- Small group participation in responses to simulation-based tasks that demonstrate feedback and coaching
- Play recording of student thinking aloud during cognitive lab
- Small group participation in Reflection Activities to experience transfer of model levels to new ecosystems and forms of student collaboration in the jigsaw tasks.
- Summary of research findings
- Discussion questions
- Potential future collaboration

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# Leveraging Tool Support for the Analysis of Computer-mediated Activities

## Organizers

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 Carolyn ROSÉ, Carnegie Mellon University, USA, [cprose@cs.cmu.edu](mailto:cprose@cs.cmu.edu)

## Tutorial Description

The analysis of multimodal computer-mediated human interaction data, such as that often found in CSCL and related fields, is difficult: the diverse nature of this data and its sheer quantity is challenging enough, but a further obstacle is introduced by the complex nature of these interactions (Dyke et al., 2009). A recent series of workshops on the topic of productive multivocality in CSCL research has shown the value, both of using tools to support the creation and sharing of analytic representations, and of using state of the art language technologies to help explore corpora of discussion data.

It has been our experience that, when researchers are not also tool authors or working in close collaboration with tool authors, they rarely use the full potential offered by the state of the art in analysis software. We hypothesize that there are three principal reasons for this situation. Most tools rarely develop beyond “research prototype” status, leading to poor usability and documentation, and few resources available for maintenance. Furthermore, the cost of setting up prior to be able to perform analyses (installation, learning to use the software, data import) is often great or hard to evaluate. Last, it is often very hard to assess whether a given tool is suited to the researcher’s need (each need having a slightly ad-hoc component making comparison with other cases difficult). In spite of these problems, analysis tools do have the potential to save time and allow researchers to focus on the kinds of analytic work which can only be performed by humans, as opposed to the more “menial” tasks which can be delegated to a computer.

In this tutorial, we explore how two such tools ([Tatiana](#)<sup>1</sup> and [SIDE](#)<sup>2</sup>, both of which are freely downloadable) can be of use to researchers in the learning sciences and who would like to:

- Collect and analyse multimodal and multimedia data (e.g. video and log files, in concert)
- Create interactive visualisations which help explore and examine the data
- Record annotations, codes and relationships between events
- Share analyses with other researchers (advisors, collaborators, etc.)
- Combine multiple analytic perspectives
- Use language technologies to assist coding and labelling
- Use language technologies to explore and summarize large quantities of data
- Find patterns of interest and statistical outliers

This tutorial will focus on three phases:

1. Review of the state of the art on computer models for analysis (Dyke, 2010), its limitations and related methodological issues
2. Hands-on overview of SIDE and Tatiana and their functionalities, using analyses from the authors’ previous work
3. Free tutored time using the tools to perform analyses, based as much as possible on participants’ own research questions on their own data and/or provided sample corpora.

Throughout the tutorial, we will draw on our experience in the multivocality workshops to help participants relate their tool usage to their research practices and methodologies, in order to better understand the limitations of the state of the art and the analysis opportunities which it provides to the CSCL field.

Based on desires expressed by participants, we may also explore how existing tools might be extended to meet new analytic needs, but do not expect this to be a key focus.

## Participants

This tutorial is aimed at researchers from the CSCL community in general, most specifically those who are interested in the detailed analysis of online or face-to-face conversations. Prospective participants should submit a statement of interest to [gdyke@cs.cmu.edu](mailto:gdyke@cs.cmu.edu) that briefly (2-5 paragraphs) presents their prior and current work, typical methodologies and their expectations for the tutorial.

As we would like to support researchers who are looking for tools to solve their analytic problems by giving them the opportunity to examine their data in SIDE and Tatiana, prospective participants may optionally submit a dataset for which we will provide assistance in import to Tatiana and SIDE prior to the workshop. Such data sets should:

- Include timestamped transcripts, either of online discussion or video recordings.

- Be in a machine readable format (Excel, XML, CSV, etc.)
- Optionally be partially analyzed (codes, annotations, etc.)
- Include as complete a description as possible of the research and pedagogical context the dataset is taken from.

If you wish to submit a dataset, please describe it in your statement of interest.

Accepted participants will receive a set of dataset descriptions (the accepted datasets plus a few sample datasets provided by the organisers). Prior to the event, they will be expected to choose one of these datasets and a research question related to it, which they will plan to explore during the third part of the tutorial.

Participation is limited to 15 participants. We will accept up to 3 datasets. Priority will be given to young researchers and researchers whose typical methodologies are deemed best suited to computer-assisted analysis.

## Introduction to Social Network Analysis Theory and Its Application to CSCL

### *Organizers*

Christophe REFFAY, UMR STEF - ENS Cachan, 61 avenue du President Wilson 94235 Cachan cedex, France,  
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Alejandra MARTÍNEZ-MONÉS, GSIC-EMIC, University of Valladolid, ETS de Ingenieria Informatica,  
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### Who is This Tutorial Designed for and What for?

You are a researcher from one of the various disciplines that CSCL has attracted. You are analysing CSCL situations, or designing and developing tools to support such collaborative learning situations. In your personal or professional life, you may have taken part in the early social networking wave on the Web2.0 by using Facebook, LinkedIn, Twitter, Ning, Blogger, or Diigo (among the most famous) and got some advantages (or not) from this high connectivity with others. But until now, you did not take time to get informed on Social Network Analysis as a conceptual framework that could give you a complementary interpretation of your data when they can be described as networks.

This tutorial has been designed by Christophe Reffay and Alejandra Martinez-Mones, both with wide experience in applying Social Network Analysis theory and techniques on collaboration analysis in CSCL situations. It is especially designed for researchers who want to take the opportunity of their presence at the CSCL conference to:

- See and experiment the basic concepts of Social Network Analysis,
- Decide whether Social Network Analysis can be applied in their own research,
- Get general and CSCL specific references to deepen their knowledge and understanding on Social Network Analysis and its use in our field and
- Experiment with practical Social Network Analysis tools and techniques and get advice on what is available and on what start with.

### What is Social Network Analysis?

Social Network Analysis is an original approach to analysis that focuses on the study of the relationships among members in a community or a group. It affords formal and intuitive ways of studying collaboration.

Social Network Analysis is a new conceptual and methodological perspective for the study of social groups. Although the foundational ideas emerged around 1930, it was not until 1970 when it started to appear as an interdisciplinary science, in parallel to the development of new theories and the generalization of computers. From then on, it has experienced a fast development, and it has been applied to studies in very diverse domains, such as organizational sciences, medicine, politics, information flow in Internet, complex systems and more recently, to the analysis of the social networking phenomena.

SNA has a relevant presence in our community, with an increasing number of papers that employ it in the last conferences since 1999. It has been used by CSCL researchers and practitioners for different goals, ranging from research on social structures, to mixed-evaluation methods, or as a tool to regulate students' behaviour.

Besides this, SNA is based on formal methods expressed in mathematical terms. This means that it is well suited to be applied by automatic methods and tools. In fact, the construction of tools that exploit this potential to support evaluation or regulation is a research topic in itself in our community.

### What Will This Tutorial Look Like?

The theoretical part will fully explain basic concepts (path, distance, diameter, density, cliques, clusters) and give an overview of the most important properties (centrality, betweenness, cohesion, multiplexity) and results (social capital, coalitions, collaboration patterns, the strength of the weak ties, etc.). These definitions and properties will be illustrated using well-known sociograms from the literature, as well as from new ones, created from scratch involving the participants of the tutorial. A second part will show how SNA has been used in CSCL research during the last twelve years. The afternoon will be more practical, interactive and participant centred. Each participant can bring his/her own dataset in order to work on it (eventually, send it to the organizers in advance). 4 datasets will be proposed by organizers to pairs of participants for transformation and analysis in order to promote interaction and different interpretations of the data. The practical session will finish with a discussion of possible future uses of SNA by the researchers, which should be inspired by the theoretical



and practical work, as well as by the discussion about related work on applications of SNA to CSCL. All suggestions may be discussed by the group to help each one to refine his/her project.

### **How to Participate?**

CSCL being a growing community, and Social Network Analysis increasingly converging on a number of subjects in our community, we expect that a lot of researchers would be interested in participating to this tutorial. So, in order to maximize the benefit of the audience, organizers suggest to participant candidates, to send a short presentation (20 lines) summarizing: their discipline, domain and research interest, their objectives in participating in this tutorial, and their ideas on why and how to (eventually) use SNA in their future work. This should help organizers to adjust the tutorial level, language and content.

## Part 5



# Pre-conference events: Workshops

## Designing Digital Curricula and Visualizations in the New WISE Environment to Facilitate Collaborative Science Learning

### *Organizers*

Hsin-Yi CHANG, National Kaohsiung Normal University, Taiwan, hsinyichang@nknucc.nknu.edu.tw

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Keisha VARMA, Ph.D., University of Minnesota, keisha@umn.edu

Jennifer CHIU, Ph.D., University of Virginia, jlchiu@virginia.edu

### **Tutorial Description**

In this tutorial we will introduce the new Web-based Inquiry Science Environment (WISE 4.0) developed at the University of California, Berkeley. WISE is a powerful, free-access online learning environment that supports guided inquiry, embedded assessments, peer collaboration, interactive computer models, and teacher customization. As WISE allows sharing and adapting curricula in many different languages, in this tutorial we will introduce how to use WISE curricula in a global context. We aim to spur international collaboration to advance the understanding of designing effective digital curricula to support students' inquiry learning in different places around the world. Participants will have a first-hand experience in learning how to use the powerful features in WISE 4.0 to adapt or customize a WISE curriculum for their own classroom. Participants will be guided to use the empathic design principles and the flexible features of embedded assessments in WISE. In particular, we will focus on how to apply the knowledge integration perspective to design learning activities and embedded assessments that foster student collaboration and science learning. These curricular steps elicit students' repertoire of ideas on science, facilitate their knowledge integration processes, open discussion for knowledge sharing and community building, and offer teachers opportunities to evaluate student understanding. Sample WISE steps and student data will be examined and discussed.

## How to Integrate CSCL in Classroom Life: Orchestration

### *Organizers*

Miguel NUSSBAUM, Pontificia Universidad Catolica de Chile  
Pierre DILLENBOURG, Swiss Federal Institute of Technology in Lausanne  
Frank FISCHER, University of Munich  
Chee-Kit LOOI, Nanyang Technological University, Singapore  
Jeremy ROSCHELLE, SRI International  
Contact: [orchestration2011@gmail.com](mailto:orchestration2011@gmail.com)

### **Workshop Content**

This half day workshop is related to the CSCL2011 theme of connecting computer supported collaborative learning to policy and practice. The adoption of CSCL practices into schools requires a holistic perspective of how such practices can be orchestrated in the classrooms, which can then inform policy makers on how best to support such orchestration.

We use the term orchestration referring to the coordination of technology-enhanced processes of learning and instruction on different social levels (individual, small group, plenary) in the classroom. Main focuses are (a) how external and internal control of learning processes play together and interact in classroom-based collaborative learning and (b) how scaffolding (for example with external collaboration scripts on different social levels can be designed to have synergistic effects on the transition from external to internal control of the collaborative learning processes (internal scripts), as well as domain learning. CSCL technology can support external collaboration scripts in activating internal collaboration script by scaffolding roles, activities, and sequences of roles or activities. In addition to digital technologies, the physical environment is also a research target.

It is therefore, about the description of how CSCL scenarios are integrated into classroom ecosystems. Does the scenario include both CSCL activities with other aspects of classroom life (reading, lectures, etc.)? How are the teams physically organized in the classroom? Do the scenarios build on non-computational resources such as paper documents, rock samples, environmental measures, etc.? How is the teacher driving the scenario, for instance changing team composition, interrupting activities, monitoring teamwork? What is the place of the CSCL activity in the curriculum and with respect to the assessment?

By "classroom", we refer to the physical place in a school, a university or a corporate training center, in which there are learners and someone responsible for their learning (teacher, tutor, coach, trainer, etc). The scope of the workshop does not address virtual classrooms or informal learning.

### **Participation Procedure**

Interested participants are asked to submit a short paper (up to 4 pages including a 150 word abstract and references) to [orchestration2011@gmail.com](mailto:orchestration2011@gmail.com) that describes a quantitative or qualitative study under the angle of orchestration, i.e. the classroom processes. To encourage group discussion up to 25 papers will be considered. Accepted participants will present their work during the interactive sessions.

## Connecting Levels of Learning in Networked Communities

### *Organizers*

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 Christopher TEPLOVS, Copenhagen Business School, [teplovs@cbs.dk](mailto:teplovs@cbs.dk)  
 Maarten DE LAAT, Open Universiteit Nederland, [maarten.delaat@ou.nl](mailto:maarten.delaat@ou.nl)  
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 Sam ZEINI, University Duisburg-Essen, [zeini@collide.info](mailto:zeini@collide.info)

### Workshop Description

This workshop is for researchers in CSSL and related fields who seek to understand how learning takes place in the interplay between individual, small group and collective (community or networked) levels of activity in "online" or Information and Communication Technology-mediated settings. We will address concomitant questions concerning how theories at multiple levels of analysis articulate with each other or explain phenomena across levels, and how methods for local analysis (e.g., process oriented microanalysis) can be coordinated with methods for global analysis (e.g., structural social network analysis). Examples of relevant research questions include:

- How does learning takes place through the interplay between individual and collective agency?
- How are local phenomena (individual and small group activity) aggregated (e.g., via stigmergy) to lead to emergent phenomena that create resources, contexts, or value that are then available for individual and small group learning?
- How are advances in community knowledge (knowledge building) driven by local activity?

The workshop will examine theoretical and methodological approaches to these questions in conjunction with each other, for example:

- Do the different levels of analysis need different theories that then must be articulated with each other?
- Are there theoretical perspectives that themselves bridge the levels of analysis?
- How can (for example) sequential analysis of interaction, content analysis and social network analysis be coordinated to address these issues?
- How can we use aggregate levels of analysis to figure out where to "dive in" for local analysis, for example to make sense of results at the aggregate community level, or to find local sources of innovation?
- What practical techniques such as different forms of triangulation or visualization techniques help connect the different levels of analysis?

### Format and Roles

This will be a one day workshop. It will include framing presentations by organizers and, according to the submissions we receive, analyses of shared data corpora by several analysts, and small group and full group discussion of related topics. Potential participants may request one of the following roles:

#### Data Presenter/Analysts:

Researchers who have a corpus that potentially illustrates learning phenomena at multiple levels and can make it available to other workshop participants in advance. They will summarize the data (setting, how collected, etc.) and present their own multi-level analysis.

#### Analyst:

Researchers who have approaches to analyzing learning at multiple levels who will be given access to the data and conduct their own analyses for presentation in the workshop.

#### Discussant:

Researchers who have theoretical and/or methodological orientations that might inform the question of connecting levels of analysis, and are asked to comment on what we learn from the above analyses.

#### Concept Presenters:

Participants who are not prepared or not selected to play the above roles but who have some concept at theoretical or methodological levels that organizers judge to be of potential value. They may be asked to give brief presentations.

#### Basic Participants:

Persons with an interest in the topic but who are not prepared or not selected to play the above roles. They will be welcome to participate in all open discussion.

## **Applying for Participation**

All interested researchers should submit up to two pages summarizing their relevant prior experience, their objectives in participating in this workshop, and a bibliography of relevant publications or an URL providing further information on the researcher's work. The abstract should indicate which of the types of participation discussed above is requested: Data presenter/analyst, Analyst, Discussant, brief Concept presentation, or Basic participation. Those who propose Concept Presentations should submit one additional page on a concept that can be presented in 5-10 minutes. Researchers who wish to be selected as Analyst or Discussant should submit up to two pages characterizing their theoretical and/or methodological approach to connecting levels of learning. Potential Data Presenters should meet the requirement for Analyst and also submit up to two pages summarizing the nature of the corpus and making the case that this data will serve the objectives of the workshop. Data Presenters are encouraged to contact organizers in advance to discuss the corpus.

# Discussing and Synthesizing Three Positions in Computer-supported Inquiry Learning from a Design Perspective: Mobile Collaboratories, Emerging Learning Objects, and Personal Inquiry

## *Organizers*

Daniel SPIKOL & Marcelo MILRAD, Linnaeus University, Sweden  
Astrid WICHMANN, Ruhr University Bochum, Germany  
Ulrich HOPPE & Jan ENGLER, University Duisburg-Essen, Germany  
Ton DE JONG, University of Twente, Netherlands  
Roy Pea & Heidy Maldonado, Stanford University, United States  
Eileen SCANLON & Canan BLAKE, Open University, United Kingdom  
Claire O'MALLEY, University of Nottingham, United Kingdom  
Stamatina ANASTOPOULOU, National and Kapodistrian University of Athens, Greece

## Workshop Description

This hands-on workshop convenes researchers, educational designers and learning-technology architects to use and discuss different design approaches as a means to better support inquiry learning projects and practices. Participants will use different design tools to discuss the challenges in implementing classroom and field activities based on pedagogical approaches such as personal inquiry, emerging learning objects, and mobile collaboratories. Participants are requested to submit short position statements (500 words) with design challenges they encountered and present related inquiry-based learning systems. Participants can additionally links to videos or and demos to their own collaborative inquiry-based learning systems in relation to their paper. The aim of the workshop is to gain insight into design approaches for pedagogical and technological for better designing collaborative inquiry-based learning.

## Background

This workshop argues for the need to examine different design approaches to explore and promote innovative educational practices supported by collaborative technologies. Bringing the design process to the forefront to support research and the realization of products for CSCL can help to balance the different needs of researchers and practitioners. The goal of the workshop is to use the perspectives of three projects (Science Created by You, LETS GO, and Personal Inquiry) as a starting point for discussion. Additionally, the organizers will select new perspectives drawn from the participants to discuss how design processes can support CSCL research. The main outcome of the workshop is to identify key themes that can be further developed to support and improve the design of collaborative inquiry learning research and the development products.

## The Three Starting Perspectives

Science Created by You (SCY) is a project on learning in science and technology domains. SCY uses a pedagogical approach that centers on products, called “emerging learning objects” (ELOs), that are created by students. Students work individually and collaboratively in SCY-Lab (the general SCY learning environment) on “missions” that are guided by socio-scientific questions.

LETS GO frames its vision of “open inquiry” as the opportunity to catalyze and sustain global learning using mobile science collaboratories that provide open software tools and resources, and online participation frameworks for learner project collaboration, mobile media and data capture, analysis, reflection and publishing.

PI (Personal Inquiry) explores how to make the processes of evidence-based scientific inquiry personally relevant and readily accessible to young people (aged 11-15 years). The approach of PI focuses on scripted inquiry learning where learners carry out scientific explorations supported both by their teachers and also by nQuire, a personal inquiry toolkit. PI also aims to support the continuity of science learning between classrooms and non-formal settings through collaborative and individual learning activities.

## Intended Audience

We invite researchers working in the fields of educational technology, math and science learning (but not limited to) who are interested in designing and running activities in inquiry-based environments. Participants should ideally have experiences in designing or using software to support science classroom or outdoor learning activities.

## Participation Requirements

Participants are asked to submit position statements (max. 650 words) in which they illustrate design problems related to the design, evaluation, and implementation of inquiry learning that, they would like to discuss during the workshop. If participants want to present an inquiry-learning system, then additional material may be requested. The statements should include cases or problems with respect to areas of content (e.g. challenges for orchestrating mobile activities as part of larger inquiry learning), envisioning inquiry-based learning activities resulting in pedagogical scenarios (e.g. develop a concept map, run field experiments etc.). A Wiki will be provided to aggregate information about the workshop and input from the participants.

## Selection Process

Participants' proposals will be reviewed by three of the workshops organizers to determine participation.

## Duration of Event (half day or full day)

Full Day

## Description of Format and Schedule of Activities Planned

The workshop is divided into four sessions that include discussions and hands-on work with the different design processes across the projects. The first session contains a brief overview of three prominent perspectives in computer-based inquiry learning: Personal Inquiry, Mobile Collaboratories and Emerging Learning Objects. Their relevance in three ongoing science projects will be presented. Additionally, perspectives from projects from the participants selected by the organizers will be presented to seed the workshop discussions. The next session is Design Approaches that provides a set of tools for exploring how to use different design tools and processes to support the creation of inquiry learning environments. The third session consists of small breakout groups that will test out and discuss the different design tools and approaches in relation to three projects and participant's own projects. The experiences from the previous session's activities and created artifacts will inform the fourth session, the debriefing session. The aim of this final session is to discuss how inquiry based science learning supported by technology can be implemented more effectively in schools through exploring design approaches and what challenges this creates for the research, design, and eventually practice.

### Session 1: Introduction

We will provide a setting in which the challenges of developing inquiry learning activities for computer-based learning environments will be described and discussed. Broad design requirements for creating and running activities will be identified specifically describing the design challenges from the different perspectives that include Emerging Learning Objects, Mobile Collaboratories, and Personal Inquiry and the participants.

### Session 2: Design Approaches for Inquiry Activities

A set of design tools and processes will be presented that include research and professional practices. These tools are drawn from interaction, product, and learning centered design practices. Each of the breakout groups will use different tools to explore how design approaches can be used to better support inquiry learning to "work well". The set of tools provide a means for the participants to get familiar with discussing the design experiences of the three case studies from different perspectives that include technology, users, emerging learning objects, the learning goals, and societal implications.

### Session 3: Breakout Groups for Design Workshops

This is the main part of the workshop in which the participants form small groups and use the design tools introduced in the previous session. The teams apply the tools to analyze and discuss the different projects. Each of the groups will have access to the tools, such as paper based cards, white boards, and assorted pens and papers to support their design discussions. The aim of this session is for each group to generate some key discussion points related to the theme of their group for session 4.

### Session 4: Debriefing and Discussion: Evaluating Inquiry Activities

The final activity of the day is a group debriefing on the use of the three different design tools. The aim of this group discussion is cover topics such as scalability, sustainability, open standards and source, and teacher support for improving inquiry knowledge. The discussion will continue with the aim of identifying key design issues for the future of inquiry-based science learning with technology.



**Relationship to Similar Events Conducted in the Past (e.g. at CSCL or ICLS)**

This is an evolution of the CSCL 2009 workshop “Mobile Science Collaboratories to Support Open Inquiry” and the ICLS 2010 workshop, “Three Perspectives On Technology Support In Inquiry Learning: Personal Inquiry, Mobile Collaboratories, and Emerging Learning Objects”. Based on the experience from running these workshops, we have shifted the focus to different design approaches as means to discuss inquiry based learning supported by collaborative technologies.

**Minimal and Maximal Number of Participants Expected**

Ideally between 12 and 24 people

**Related links**

The workshop blog <http://blogs.celekt.nu/cscl/>

## Part 6



# Doctoral consortium

## Robotics for CSCL

### *Organizers*

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Hiroshi ISHIGURO, Osaka University  
Takayuki KANDA, ATR Japan  
Hajime SHIROUZU, Chukyo University

### Workshop Description

Automated as well as remotely controlled robots have a high potential to expand our research and practice design of CSCL in some fundamental ways. Having a robot participate in collaborative learning settings, we could control some part of the collaborative activities to better understand the basic mechanisms of collaborative learning, and to grasp and to implement basic design principles of group activities. Robots can also help us understand functions of reflection better, for example by providing learners with precise replay of past learning experiences upon requests, which has not been possible by humans.

One of our motivational factors to go into this direction is the need for us to better equip ourselves with stronger sets of evidence of the power of collaborative, learner-centered orientation in education, to work effectively with policy-makers.

In this workshop, we plan to gather both robotics-oriented learning researchers as well as learning science researchers including policy-makers who are seeking new ways to do research and practice. After some demonstrations of robots' capabilities and preliminary results taken from real classroom collaborative leanings with robots, we structure the workshop into intense discussion on exploring robots' potentials for future research and practice. We also wish to look into international collaboration possibilities of robotics in CSCL.

### Format

This will be a one day workshop. It will include framing presentations by invited speakers as well as additional presentations selected from submissions we receive, and small group and full group discussion of relevant topics.

We plan to spend the morning to share and review our preliminary research and explore possibilities of using robots to enhance CSCL research and practice.

1. Possibilities of using robots in theoretical research.
2. Possibilities of implementing robots as collaborators in real classrooms.
3. Explorations of international research collaboration.

In the afternoon we plan to identify research topics and agendas for possibly research methods, to be discussed in small groups in the birds of feather fashion. Toward the latter part of the afternoon, we will share outcomes of small group discussion, which would lead into full group discussion.

### Participation Procedure

If you are interested in participating, please contact Naomi Miyake at [nmiyake@p.u-tokyo.ac.jp](mailto:nmiyake@p.u-tokyo.ac.jp). People who have not done learning research using robots, or those who has experience of using agent-robots, are also welcome. Please come with innovative, new ideas to help promote the basic research in learning sciences.

## CSCL 2011 Doctoral Consortium Workshop

### Co-Chairs

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### Introduction

The CSCL 2011 Doctoral Consortium Workshop, designed to support the growth of young talents in the field of CSCL, provides an opportunity for advanced Ph.D. students to share their dissertation research with their peers and a panel of faculty serving as mentors. Participants will engage in collaborative inquiry and scholarly discourse to improve their dissertation work and to advance their understanding of CSCL and the Learning Sciences in general. To benefit from the Doctoral Consortium Workshop, applicants should be advanced graduate students, and be at a stage in their dissertation research where the participants and mentors may be of help in shaping and framing the research and analysis activities.

### Objectives and Design

The Doctoral Consortium Workshop aims to:

- provide an opportunity for participants to reflect on their dissertation research and to highlight problems/issues for further discussion and inquiry;
- provide a setting for participants to contribute ideas as well as to receive feedback and guidance on their current research;
- provide a forum for discussing theoretical and methodological issues of central importance to CSCL and the Learning Sciences;
- develop a supportive community of scholars in CSCL and the Learning Sciences across countries and continents;
- collaborate and draw upon literature across countries and institutions;
- contribute to the conference experience of participating students through interaction with other participants and consortium faculty; and
- support young researchers in their effort to enter the Learning Sciences research community.

The Doctoral Consortium Workshop will last for 1.5 days scheduled during the pre-conference events.

The specific design of the workshop will vary depending on the final selected group of participants. Generally, it will include these principles and activities:

Doctoral Consortium Workshop activities are organized around small-group interactions supported with technology. During the workshop, participants will first present their research briefly to familiarize each other with their dissertation project and highlight specific aspects they would like to have further discussion on. These may include specific problems for which the student is seeking advice; intriguing issues and tensions for CSCL research generally; methodological problems that other Ph.D. students are also likely to be confronting, or issues that have the potential of stimulating discussions of theoretical and methodological significance. Then, based on the common issues and themes identified (theoretical models, research design and questions, pedagogy and technology, data collection, methods of analysis etc.) participants will form small groups supported by an expert mentor, to engage in further inquiry and discussion. Participants will work on the various problems and issues identified making reference to their own dissertation project and the broader field of CSCL within the Learning Sciences. As well, they also have the opportunity to raise questions, provide suggestions, and help each other to improve their dissertation research. After the small group interactions, participants will report their progress and new questions to the whole group. Plans for further joint activity will be discussed as well. Computer-supported design and forum interaction may be incorporated to support the collaboration among workshop participants.

### Selection Process

29 doctoral students applied from Asia, Europe and the USA as well as Israel, Mexico and Canada. We accepted 18 students, two of which could not attend, leaving us with 16 student participants.

Students were selected based on:

- a) whether the research is of high quality in whatever paradigm it belongs to (engineering, qualitative social science, quantitative social science, theoretical, etc.)
- b) whether the research fits within one of the areas of CSCL

- c) whether the student is at the right time in the thesis process to benefit from the DC (they should ideally be either designing their studies, analyzing their data, or in the case of theses where the writing is a significant part of analysis, writing their analysis.)

Optional criteria included:

- d) whether the adviser provides a good recommendation  
 e) whether the student's work — given its orientation — is likely to receive good feedback from DC mentors and other students

## Participants

Selected participants, their institution, country and title of their submission are below :

*Mayra Fabiana Angeles* (Universidad de Las Americas Puebla, Mexico) Study of the role of graphic representations and their inter-relation with written language in collaborative problem solving

*Franziska Arnold* (Knowledge Media Research Center in Tübingen, Germany) Collaborative Knowledge Exchange using Patterns

*Elizabeth Bagley* (University of Wisconsin-Madison, USA) The psychological reality of virtual environments: Assessing the development of ecological thinking in a virtual environmental education experience

*Hsiu-Mei Chang* (Graduate Institute of Learning & Instruction, Taiwan) The Nature of Knowledge Co-construction: Reconsidering Meaning-making of Postings in Online Group Discussion

*Jacob Dylan* (University of Haifa, Israel) Cyberscouts: a model for scaling-up afterschool educational gaming

*Lai Fan Fu* (University of Hong Kong) A scheme for analyzing the development of knowledge-building discourse

*Iassen Halatchliyski* (Knowledge Media Research Center in Tübingen, Germany) Social Network Analysis of Collaborative Knowledge Creation in Wikipedia

*Andrew Krumm* (University of Michigan, USA) The diffusion and implementation of learning management systems in higher education

*Chunlin Lei* (University of Hong Kong) Fostering Computer-Supported Knowledge Building through Formative Assessment among Chinese Tertiary Students

*Na Li* (Swiss Federal Institute of Technology in Lausanne, Switzerland) Trust Modeling and Evaluation in Personal Learning Environments

*Luis P. Prieto* (University of Valladolid, Spain) Activity-based tools to support orchestration of blended learning scenarios

*Annelies Raes* (Ghent University, Belgium) Web-based Collaborative Inquiry in Secondary Science Education

*Sayaka Tohyama* (Chukyo University, Japan) Supporting getting structural elements for Constructive Interaction

*Anja Rudat* (Knowledge Media Research Center in Tübingen, Germany) Can “Prominence” and “Aggression” enhance learning?

*Garrett Smith* (University of Wisconsin-Madison, USA) Supporting Progressive Idealization of Physics Understanding through a Mixed Reality Learning Environment

*Katharina Westermann* (Ruhr University Bochum, Germany) Collaborative Learning with Multiple Representations in a Computer-Based Setting

## Acknowledgements

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## **Cyberscouts: a Model for Scaling-up Afterschool Educational Gaming**

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**Abstract:** The research goal is to design an effective model to bring serious educational computer games to afterschool youth communities. This model, which we call the Cyberscouts model, suggests engaging teens in mentoring younger kids in playing virtual educational games. Following the design based research methodology, a pilot study of the proposed model was conducted and analyzed for the next iteration. 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. More confirming outcomes and challenging outcomes emerged towards the next iteration of the research.

### **Goals of the Research**

Our overarching 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 me, the author of this proposal.

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; The Design-Based Research Collective, 2003), 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 Cyberscouts 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 Cyberscouts 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.

In order to understand the design parameters of the model, the effectiveness of the Cyberscouts' mentoring, and the impact of this mentoring on the mentees (the players), the proposed research seeks to answer the following questions:

- 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?
- How would implementation of the model impact the players? How will it affect their content knowledge, inquiry skills, and attitude towards science?

### **Background of the Project**

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 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.

Therefore, 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.

## Methodology

In order to design the Cyberscouts model we are using a Design Based Research (DBR) approach (Collins, et al., 2004; Kali, 2008; The Design-Based Research Collective, 2003).

## Participants

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, 11<sup>th</sup> 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 5<sup>th</sup> to 7<sup>th</sup> (three girls and seven boys) from a school in a high socio-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 min 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.

## Current Status and Preliminary Results

A pilot study regarding the feasibility of the proposed model was conducted between Nov 2009 and May 2010. 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 first run of the model (Nov 2009 till April 2010) the leaders and the researcher met for eight co-design meetings, 60-90 minutes each. 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.

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

Out of 23 potential players that expressed an interest to sign up for the game, ten players completed the sign-up process. Out of the ten players, only four players passed the introductory unit, and two players played more than two game sessions. Following Ronen-Fuhrmann and Kali's (2008) DBR analysis approach, these 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. 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). Eventually, only 2 players (20%) 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 to the Zofim, "it will have negative connotation to many 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 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 Cyberscout 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.

## Particular Issues to Explore Further in the Discussion at the Workshop

- Co-DBR and its relevancy to CSCL, and methodological use  
The co-DBR opens up many issues that I find worth discussing. For example – when the practitioner (student) is an equal partner in the design -how to accept design decisions? What is the new role of the researcher?
- Experience with educational MUVE games in afterschool informal settings.  
I am finding that using Quest Atlantis “as is” is not so trivial in informal setting, and would like to learn if there are other projects that bring similar games to informal settings, and how they cope with the difficulties, if any.
- Community of learners in afterschool informal settings: current research, successful implementations  
The game groups can be regarded as community of learners, that exist in an informal, free-choice environment. I am interested to learn more from experience of others if there are other research projects in this area, if there are successful implementations, and knowledge-sharing with the CSCL community.
- Assessments methods for learning “in the wild”  
On one hand, I want to identify changes in knowledge and learning before and after the enactment. On the other hand, it is a free-choice environment and tests/quizzes does not seem to be the right tool. I am looking for ideas and maybe practices that can be used to assess students learning in this particular setting.

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# The Psychological Reality of Virtual Environments: Assessing the Development of Ecological Thinking in a Virtual Environmental Education Experience

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**Abstract:** This paper explores whether and how virtual environmental education (VEE) develops young people's ecological thinking skills. Specifically, I examine whether youth can develop ecological thinking through VEE by examining face-to-face and chat mentoring interactions in two conditions of the epistemic game, Urban Science, a game where youth role play as professional urban planners, interacting with adult mentors to learn about and address environmental problems. This study has the potential to impact the field in a number of ways. First, this study may provide quantitative evidence for differential effects between the face-to-face and chat conditions by using epistemic network analysis. Second, this study could contribute to a larger conversation about digital media in general and the constraints and affordances of face-to-face and virtual mentoring in particular. Finally, this study could show that young people can develop ecological thinking in virtual environmental education settings thus making environmental education accessible to more people.

## Overview

Faced with global environmental challenges, we need to prepare the next generation of leaders to understand their impact on the global system and their role in ensuring its sustainable future. In order to accomplish that task, we need to train people to think ecologically.

I am interested in understanding if and how virtual environmental education (VEE) develops young people's ecological thinking skills. In my doctoral thesis, I explore if young people can develop ecological thinking through VEE by examining face-to-face and chat mentoring interactions in two conditions of the epistemic game, Urban Science. In Urban Science, young people role play as professional urban planners, interacting with adult mentors to learn about and address environmental problems.

This study has the potential to impact the field in a number of ways. First, this study may provide quantitative evidence for differential effects between the face-to-face and chat conditions by using epistemic network analysis. Second, this study could contribute to a larger conversation about digital media in general and the constraints and affordances of face-to-face and virtual mentoring in particular. Finally, this study could show that young people can develop ecological thinking in virtual environmental education settings thus making environmental education accessible to more people.

## Background and Research Goals

With population and per-capita consumption both on the rise, scientists believe humans' impact on the Earth is no longer sustainable (Rockstrom et al., 2009). According to the United Nations Millennium Ecosystem Assessment (2005), "Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted." Thus, we need to prepare the next generation of leaders to understand their impact on the global system and their role in ensuring its sustainable future. In order to accomplish that task, we need to train people to think ecologically.

According to Code (2002), ecological thinking is intended to achieve "modes of existence that exemplify appropriate, sustainable, and beneficial relationships between human and nonhuman beings and their environments." However, educators are at odds over how to best help young people develop ecological thinking. One group of environmental educators argues that it is necessary for young people to be in the physical environment in order to learn ecological thinking (Louv, 2005) while another group posits that ecological thinking can be cultivated through virtual experiences (McGonigal, 2011).

Interacting with the physical environment can develop ecological thinking (Rydberg, 2007). In a problem-based environmental education setting like one created by Rydberg (2007), young people research environmental problems by interviewing local residents. During their interviews, they might learn that the trout population in a nearby stream has declined which might lead them to gather real-time data about the dynamics of a stream. They might use their data to build and analyze a model of the sub-basin of the watershed with help from modeling experts. Their analysis might offer concrete, tangible solutions including creating a riparian buffer zone to decrease the water temperature of the stream and increase the trout population. They could become part of the political process and see the changes through to implementation.

Unfortunately, there are limitations to developing ecological thinking in the physical environment. First, environmental problems are extremely complex, and the skill set required to build a complex model

describing the interrelationships involved with those problems is greater than the skill set required to interpret a model. Consequently, the models young people would construct without help would be inaccurate and overly simplistic because they do not have enough domain-specific content knowledge or possess sophisticated modeling skills. The second reason is logistical. Even with a complex model available, the logistical overhead involved with identifying people, carrying out interviews, teaching students the skills they need in order to run the model, and finding people with adequate experience are extremely high.

One promising alternative to the logistically and theoretically intensive experiences in the physical environment is a well-designed virtual experience. While critics touting the “last child in the woods” crisis (Louv, 2005) may be concerned that young people spend too much time in front of television and computer screens, I believe that young people need to spend more time interacting with the right kind of virtual experiences.

In my research, I am interested in understanding if and how virtual environmental education (VEE) develops young people’s ecological thinking skills. In order to explore that topic, I create the idealized educational scene described above using a computer game to provide an accessible model and lower the logistical overhead.

The epistemic game, *Urban Science*, develops ecological thinking by providing young people with access to a complex social and ecological model and professional mentors. *Urban Science* is an epistemic game modeled on the profession of urban planning (Bagley & Shaffer, 2010). In the game, young people role play as interns for a fictitious urban planning firm, and in the process develop the epistemic frame of urban planners (Shaffer, 2006a; Bagley & Shaffer, 2009). Using a custom-designed portal system, players conduct a virtual site visit where they learn what the site’s stakeholders—fictional characters in the game—consider its most important issues. Players visualize proposed land use changes using *iPlan*, a custom-design geographic information systems (GIS) tool. Through using *iPlan*, players discover that altering one variable within the complex system affects other variables, reflecting the messy, interdependent, ecological relationships present in the modern city. Players then integrate the stakeholders’ complex set of demands into a cohesive plan for community growth using *iPlan*. Throughout the entire process, players interact with mentors. The mentors provide reflective feedback aligned with the kind of feedback given in the professional practicum. Thus, using ethnographic observations of actual professional practica, epistemic games attempt to reproduce key cycles of professional activity and reflection-on-action while enabling young people to interact with complex models and reducing the logistical overhead.

In this study, I explore if young people can develop ecological thinking through VEE by examining one aspect involved with lowering the logistical overhead: face-to-face versus chat mentoring. I analyze one set of mentor-player interactions to see whether those interactions are similar or different between two conditions of *Urban Science*, one condition in which mentors and players are face-to-face and the other condition in which mentors interact with players through an internal chat program. The interactions I analyze are the reflection meetings during which the mentors asked players a set of four questions designed to encourage players to reflect on the activity they just completed and predict which activities might come next and why.

My research addresses the following research questions:

RQ1: Was the mentors’ discourse during the reflection meetings different between the two conditions?

RQ2: Was the players’ discourse during the reflection meetings different between the two conditions?

RQ3: Were the players’ exit interview outcomes different between both conditions?

I use emerging Epistemic Network Analysis (ENA) techniques (Shaffer et al., 2009) to characterize and measure the networks of epistemic frame elements represented in the player and mentor reflection meetings for the face-to-face and chat conditions. Drawing on work in social network analysis (Wasserman & Faust, 1994; Degenne & Forse, 1999; Hanneman & Riddle, 2005; Wellman & Berkowitz, 1988), ENA provides a quantitative method for measuring the systems of relations which distinguish epistemic frames (Shaffer et al., 2009). As Wellman and Berkowitz (1988) argue, one of the central reorientations of social network analysis is “to view relations as the basic units of social structure and groupings of similarly situated actors as the result.” ENA extends this idea to the networks of epistemic frames.

To address research questions 1 and 2, I explore and measure the combinations of epistemic frame elements that figure most prominently in the reflection meetings and then use these patterns to measure the similarities and differences between the two conditions. I also calculate the trajectories of epistemic frame elements over the course of the six reflection meetings and use these patterns to measure the similarities and differences between the players and mentors. To address research question 3, I use ENA to show possible differential effects between the face-to-face and chat conditions by measuring the networks of epistemic frame elements represented in the player intake and exit interviews and correlating those networks to the reflection meeting networks.

## Methodology

I address my research questions by conducting an epistemic network analysis of two data sources—reflection meetings and interviews—across two conditions—face-to-face and chat mentoring. I use epistemic network analysis to assess the epistemic frames enacted by the mentors and players during the reflection meetings across both conditions. To determine whether the reflection meetings impacted the interview outcomes, I correlate the mentors' and players' networks from the reflection meetings with the interview networks.

## Setting and Data Collection

The data for this study were collected from two conditions of the epistemic game, Urban Science. Urban Science was designed to simulate an urban planning practicum experience (Bagley, ETHNO). In the game, 21 high school aged players recruited by outreach specialists at the Massachusetts Audubon Society's Drumlin Farm Wildlife Sanctuary played a 10-hour version of Urban Science as part of a week-long Conservation Leadership Program in August 2010 (recruitment materials, appendix). Players had no prior experience with urban planning.

The two mentors in the game (called planning consultants) guided the players as they worked and lead team meetings throughout the process. The planning consultant roles were filled by a graduate student and a Drumlin Farm education specialist. Both planning consultants underwent a one-day training that covered the urban planning profession, the game's activities, and preferred mentoring strategies. In addition, the planning consultants met before each session to plan for the day's activities and after each session to reflect on those activities.

Players were randomly assigned to one of two groups. From 9:00-12:00 on Tuesday, Wednesday, and Thursday, 11 different players interacted face-to-face with their planning consultants in the room. From 12:30-3:30 on Monday, Tuesday, and Wednesday, 10 players interacted with their planning consultants through an online, internal chat program. Everything else about the two games was the same (or as close to the same as possible).

## Data Selection

In order to address the research questions stated above, I used discourse data from the reflection meetings and outcome data from the intake and exit interviews. I used data from the reflection meetings because they are the most logistically-intensive mentor activity, and they are also a key set of mentor-player interactions because according to Schön (1983; 1987) and Shaffer's (2006) ideas about how mentoring works, people learn through action and reflection-on-action and reflection-on-action turns experience into understanding. Additionally, during my ethnographic study of an urban planning practicum, the epistemic frame development occurred during feedback sessions when students were reflecting on their work and the teacher was providing feedback (Bagley & Shaffer, 2010). Thus, for my dissertation thesis, I examine the role that planning consultants play in reflection-on-action and see whether virtual reflection-on-action is comparable to face-to-face reflection-on-action.

## Reflection Meetings

During the six reflection meetings, the planning consultants asked a series of four questions (the first two questions were asked to each individual, and the last two questions were addressed to the entire team):

1. What did you just finish doing?
2. What did you find out during that activity?
3. With the information we have, what should we do next?
4. What additional information do we need to do that?

After all players answered questions two and four, the planning consultant would revoice and extend the players' responses to include specific frame elements pre-determined to be important for that specific point in the game. The planning consultants would move onto the next set of questions after all team members agreed with the planning consultant's assertion. The revoicing after the fourth question transitioned the players into the next activity.

## Segmentation

In order to make claims about individuals, the reflection meetings were segmented and coded at the conversational turn level. I then segmented the data by topic using the 4 questions asked during each meeting as the topics and sum the SKIVE elements for each individual for each question within a reflection meeting. That aggregation resulted in 24 data points for each individual (4 questions asked during 6 meetings). The aggregated data was used to create an adjacency matrix. The adjacency matrix was used to create cumulative adjacency matrix where the 4 points per meeting will be aggregated to create 6 data points for each individual (one data point for each of the 6 meetings).

The interviews were segmented and coded by question. I only analyzed the questions that appeared in both the intake and exit interviews which include matched-pair questions and questions that were identical in both interviews. The final dataset includes 162 aggregated points from six reflection meetings and approximately 628 interview excerpts, 314 from the intake interview and 314 from the exit interview.

### Data Coding

In order to ground my qualitative codes in the urban planning profession, I developed codes from the American Planning Association’s description of what planners know, do, and care about (2010). I then used grounded theory (Strauss & Corbin, 1998) to develop a more-specific set a qualitative codes representing aspects of urban planning expertise. When the development of the coding scheme reached saturation (Strauss & Corbin, 1998), I mapped each of the codes to one of the five different categories of epistemic frame elements—the particular kinds of skills, knowledge, identities, values and epistemologies that comprise a professional planner’s expertise.

While coding the data, I read through each excerpt and focused on one code at a time. Each excerpt was coded for either presence (1) or absence (0) of each code. That process ensured that the data was in the proper format for a quantitative epistemic network analysis.

The validity of the coding process was checked through an inter-rater reliability analysis. An educational psychology researcher working on a non-planning domain was trained on the coding scheme and independently coded 150 randomly selected excerpts of the data. Correlation among the codes assigned by both the primary and secondary coders were checked, and all codes had a Kappa greater than 0.6 (Landis & Koch, 1977).

### Epistemic Network Analysis

Epistemic network analysis measures particular aspects of the relations among elements within an epistemic network. The process begins by converting data segments into adjacency matrices in order to calculate the frequencies of co-occurrence among the elements. To illustrate, a hypothetical individual segment of reflection meeting data coded for the presence of each of the five primary epistemic frame elements would be converted from a single row:

Skill	Knowledge	Identity	Value	Epistemology
1	0	1	1	0

to an adjacency matrix:

	Skill	Knowledge	Identity	Value	Epistemology
Skill	0	0	1	1	0
Knowledge	0	0	0	0	0
Identity	1	0	0	1	0
Value	1	0	1	0	0
Epistemology	0	0	0	0	0

where the intersection of each row with each column represents the co-occurrence (marked with a ‘1’) or lack of co-occurrence (marked with a ‘0’) between the respective coded frame elements for that row and column. When a pair of elements co-occur within a stanza, they are considered conceptually linked (Shaffer, 2010).

From the resulting symmetric adjacency matrix, the emerging “shape” of this network can then be quantified by treating each element as a node and their co-occurrences with other elements as links. In this example, the resulting network could be visualized as three nodes, Skill, Identity, and Value, each linked to the others, and the nodes Knowledge and Epistemology not linked to any other node.

This adjacency matrix can then be turned into a cumulative adjacency vector where each player and mentor has one vector for each reflection meeting for each SKIVE element. To control for the variable excerpt length, I normalize the values by dividing them by the square root of the sum of squares for the vector they are part of. The adjacency vectors can then be run through a multi-dimensional scaling (MDS) algorithm to reduce the vectors to the major dimensions. Using these deep-level components in conjunction with more superficial aspects of the text (i.e., total number of sentences, total number of words, and words per sentence), we can predict how face-to-face and chat reflection meetings might differ in Urban Science (Clark, 1991; Clark, 1996; Graesser, 2007).

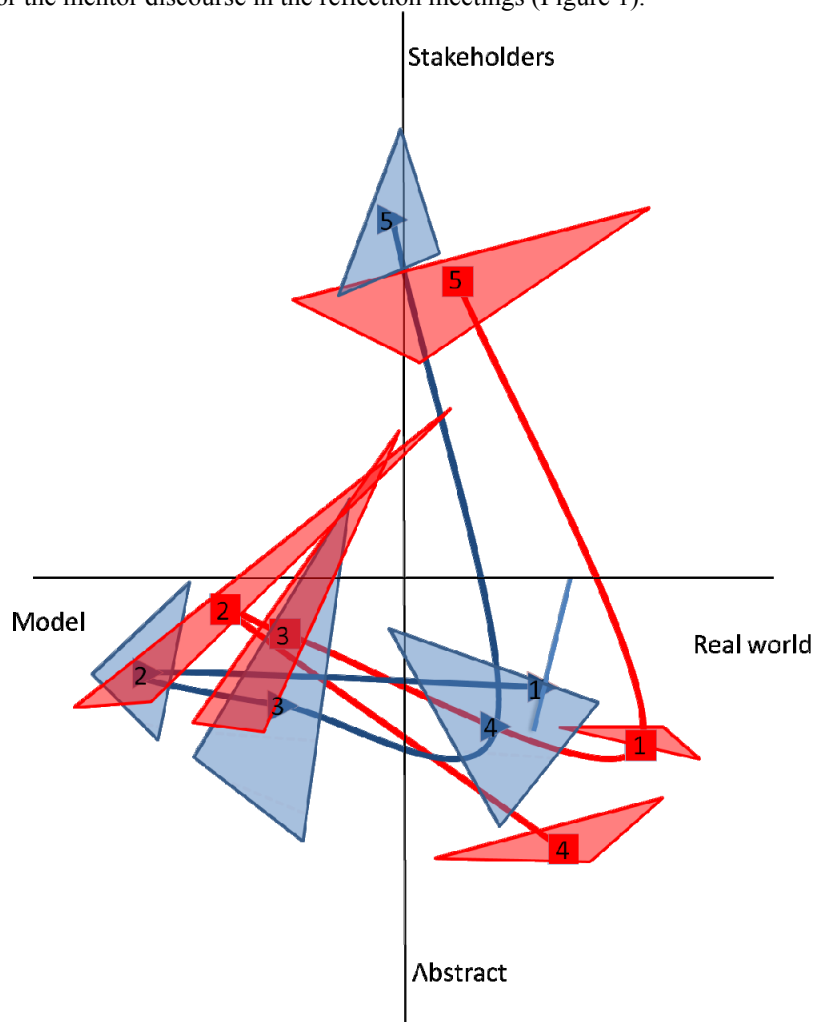
From a multidimensional space, it is possible to create two dimensional trajectories using a MDS method. Using MDS, the eigenvectors that capture the most variance are calculated from the normalized cumulative adjacency matrix. The MDS routine transforms distance vectors from a distance matrix into points within the eigenvector’s space by multiplying the original distance vectors by the eigenvectors. Two of the transformed vectors are then chosen to represent the x and y axes in the epistemic frame trajectory projection.

## Current Status

Currently, I am using ENA to analyze data from the chat and face-to-face conditions of Urban Science. I am completing a literature review about the constraints and affordances of virtual mentoring and the importance of ecological thinking.

## Preliminary Results

In order to test the potential of using ENA for the kind of data I am proposing to analyze, I used MDS to create two dimensions for the mentor discourse in the reflection meetings (Figure 1).



**Figure 1.** MDS dimensions for the mentor discourse in the reflection meetings. The red (chat condition) and blue (face-to-face condition) shaded triangles represent the individual mentor points for each reflection meeting (three points/meeting except for meeting one when two face-to-face teams met together). The points along the lines are the average values for each meeting, and the line connects those meetings over time.

Though the analysis is still at a very preliminary stage, these results show that MDS can be used to create dimensions that seem to align closely with the qualitative data. For example, the qualitative data suggest that the y-dimension corresponds to mentors talking about stakeholders (with the 5<sup>th</sup> meeting having the most discussion about stakeholders). The qualitative data also suggests that the x-dimension corresponds to mentors talking about the real world versus the simulated world (the iPlan model). In my future analyses, I plan to examine additional dimensions and apply this technique to the player data.

## Web-based Collaborative Inquiry in Secondary Science Education

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**Abstract:** Educational research, as well as national standards, support collaborative learning and the integration of ICT as an answer to the decreased interest in science learning. In this respect, this research project deals with the use of Computer Supported Collaborative Learning (CSCL) as a promising approach for secondary science education. The overall study is driven by three main research questions. First, we want to investigate the contribution of CSCL in secondary education on three science outcomes: knowledge integration, inquiry skills and motivation for science. Second, we were are interested in the differential impact among different groups of students and third we question under what conditions the learning environment is most beneficial. This study is set up from a design-based research approach which means that we implement the CSCL-project during several iteration in authentic classroom setting to study our research questions. Around 15 secondary science classes and 350 students are involved.

### General Goal and Background of the Research

The PISA results reveal that Flanders belongs to the group of OECD countries which achieved very high results for scientific literacy. On the other hand, in comparison with the 15-year-old students in the average OECD country, fewer Flemish students reported that they are motivated to learn science, and only an absolute minority saw themselves working in science related jobs later on (De Meyer, 2008). One of the reasons for young people's lack of interest in science is that much of what goes on in science classrooms is not particularly attractive to students (Flemish governmental enquiry, 2005).

Recently, web-based collaborative inquiry has been considered as a promising innovative instructional approach in the attempt to make science accessible and interesting to all (Slotta & Linn, 2009) and to meet the national standards that stress the growing importance of scientific inquiry skills. During web-based inquiry projects students are faced with information problems, i.e. tasks that require them to identify information needs, locate corresponding information sources, extract and organize relevant information from each source, and synthesize information from a variety of sources (Brand-Gruwel, Wopereis, & Vermetten, 2005). Since teenagers are given different names that emphasize their affinity and tendency to use digital technology, such as digital natives (Prensky, 2001), the Net Generation (Tapscott, 1998) and Screenagers (Rushkof, 1997) it is often assumed that modern-day students are empowered and/or perceive themselves as empowered by their experience with ICT and thus might consider themselves to be better learners compared to former generations. However, this is confirmed by only a third of the interviewees in the study of Kolikant(2010). Student's lack of regulation skills has already been indicated by several studies across the world (Quintana, Zhang, & Krajcik, 2005; van Joolingen, de Jong, & Dimitrakopoulou, 2007). Consequently, students need a specific and systematic way of scaffolding to support the complex cognitive skill of information problem solving.

In this respect, the purpose of this doctoral research is to investigate the implementation of web-based collaborative inquiry in Flemish secondary science education and question how this CSCL-practice can be orchestrated in the classrooms. The overall study is driven by three main research questions. First, we want to investigate the contribution of CSCL in secondary education on three science outcomes: knowledge integration, inquiry skills and motivation for science. Second, we were are interested in the differential impact among different groups of students and third we question under what conditions the learning environment is most beneficial. More specific, we want to focus on the scaffolding issue in order to attain more successful inquiry instruction within an authentic classroom setting. Because it is found that in the dynamic, complex environment with groups of learners in a classroom, not all of the necessary scaffolding could be provided with only one tool or agent (Puntambekar & Kolodner, 2005; Tabak, 2004), it is suggested to present and study multiple forms of support and multiple learning opportunities to learn science successfully. We differentiate between 1) scaffolds that are embedded in the technology-enhanced learning environment (Puntambekar & Hubscher, 2005; Reiser, 2004), 2) the teacher's role to effectively coordinate and support technology-enhanced processes of learning (Azevedo, Moos, Greene, Winters, & Cromley, 2008; Pea, 2004), and 3) the support learners get from their peers through collaboration (Lazonder, 2005; Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003). Nonetheless, little is known about how the teacher can foster effective collaborative inquiry (Webb, 2009) and research on collaborative web searching is scant (Lazonder & Rouet, 2008).



## Methodology

This research project is driven by a design-based research methodology, a well-established research approach in the Learning Sciences (Barab & Squire, 2004; Brown, 1992; The Design-Based Research Collective, 2003). This approach is characterized by a holistic perspective and the implementation of educational innovation (in this case web-based inquiry learning) in an authentic and realistic school setting and aims at understanding how, when, and why educational innovations work in practice. This study is embedded in a larger multiphased research project that extends over five years. Several iterations will be conducted in order to refine our understanding of learning issues involved as well as to define new design principles. By now, two iterations of the study are already finished. We are working together with around 15 secondary school classes (grade 9 and 10), which means that every year about 350 students participate in this project.

This research project relies on multiple sources of evidence, both quantitative and qualitative, which are triangulated. The quantitative part of the study focused on pre-post-test-comparisons using knowledge acquisition tests, inquiry tasks and questionnaires. For the qualitative part of the study, we've already organized focus-group interviews with the classroom teachers to get insight in design challenges and a more in depth study is planned to investigate involved processes in collaborative Information Problem Solving.

## Overview of the Academic Work and Future Planning

### First Research Cycle (2008-2009)

#### Research Questions

The first study dealt with the implementation of web-based collaborative inquiry as an innovative instructional approach for secondary science education. In particular, a Web-based Inquiry Science project created within the Knowledge Integration framework (Slotta & Linn, 2009) is put into educational practice. The inquiry-based learning environment used in this study was the Web-Based Inquiry Science Environment (WISE) and a Flemish WISE-curriculum project about Global Warming was designed in partnership with science teachers and technology specialists. The total project consisted of four main inquiry learning activities spread over 4 sessions of 50 minutes each. Table 1 shows the issues, concepts and questions that students had to generate and investigate during the WISE-project.

The effects were investigated on students' knowledge acquisition, their inquiry skills, and their attitude toward science. Because schools face a challenging task in providing adequate instruction to meet the needs of a diversity of students, the focus was on whether web-based inquiry could be beneficial for all students. We compared different groups of students, i.e. boys and girls, high- and low-achieving students in science and differentially tracked students.

Table 1: Content and structure of the Web-based learning project 'Global Warming and Climate Change'.

Four main learning activities	Research questions students had to generate and investigate	Specific learning tasks
1. The problem	# How has the earth's climate changed in the past? # What might happen to the climate in the future?	-Interactive visualization of the greenhouse effect -Searching for evidence on the world wide web
2. The causes	# What are the potential causes for changes in the global climate? # Are human activities or natural processes the main cause for global climate change?	- Online classroom debate - Analyzing CO <sub>2</sub> -emissions trends across different countries in the interactive graph Gapminder World
3. Consequences	# What is the impact on people and on the natural environment? # Differential effect on wealthy and poor countries?	- Searching for evidence on the world wide web - Exploring provided video material
4. Solutions	# How can you help protect the climate? # What is the world's policy in combating climate change?	- Calculating their own ecological footprint and reflecting about this information - Exploring and discussing the outcomes of the latest United Nations Climate Change Conference

**Method**

An empirical study in 19 secondary science classes involving 370 students was conducted. The quantitative part of the study focused on pre-posttest-comparisons and the analysis of the differential impact among groups. For the qualitative part of the study, focus group interviews were organized with the classroom teachers to get insight in design challenges.

**Results**

The study demonstrates the effectiveness of this innovative instructional approach in the attempt of making science accessible and interesting to all. In particular this approach offers advantages for students who are not typically successful in science, i.e. girls, low achievers, and students from a general track.

**Output**

- Raes, A., Schellens, T., De Wever, B. (2010). *The impact of web-based collaborative inquiry for science learning in secondary education*. Paper presented at the ICLS conference, Chicago.
- Raes, A., Schellens, T., De Wever, B. (under review). *Web-based Collaborative Inquiry to Bridge Gaps in Secondary Science Education*, Journal of the Learning Sciences.

**Second Research Cycle (2009-2010)**

**Research Question**

Despite the widespread recognition of the need to scaffold students in web-based inquiry learning environments, the understanding of how students' inquiry can be supported in authentic classroom settings, is rather limited. Especially, more insight is needed in how we can foster students' information problem solving skills, a pivotal 21<sup>st</sup> century skill. To help fill this gap, the second study conducted a large-scale study in real classroom settings in which students learned about global warming and climate change through a web-based collaborative inquiry project. During this project students were faced with different information problems to be solved by means of evidence from the web. The purpose of this study was to investigate whether the presence of metacognitive and strategic scaffolds improved students' domain-specific knowledge and metacognitive awareness (i.e. knowledge about cognition and regulation about cognition). While most studies focus on technology-enhanced scaffolding, this study took also into account the role of the teacher to scaffold information problem solving on the web. Consequently, it was intended to examine the effectiveness of technology-enhanced and /or teacher-enhanced scaffolding and the way they interact with students' gender and prior knowledge level.

**Method**

Three experimental conditions (teacher-enhanced: human tutor as an external regulating agent, technology-enhanced: embedded question prompts (EQP), and both forms of support) were compared with a control condition in a two-by-two factorial quasi-experimental design. Pretest-posttest differences in students' domain-specific knowledge, strategy use and metacognitive awareness were measured. In total 347 students from 18 secondary school classes (grade 9 and 10) were involved and the classes were randomly distributed over the 4 conditions.

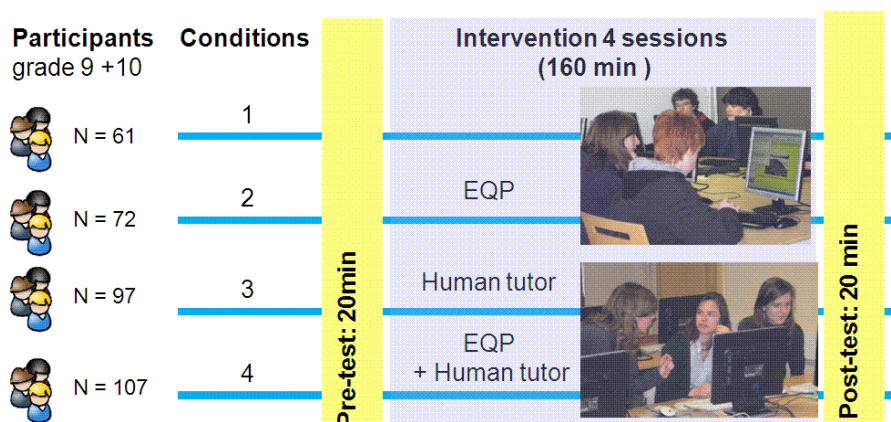


Figure 1. Procedure of the Study.

## Results

Our results indicate that learning science by means of a web-based inquiry project is effective to enhance learners' domain-specific knowledge and to enhance their metacognitive awareness. We can conclude this based on evidence for an overall increase in students' performances. However, it is found that the effectiveness of a scaffolding condition is dependent on the learning objective and students' characteristics.

With regard to knowledge construction, teacher-enhanced scaffolding is found to be a determining factor. Students provided with teacher-enhanced scaffolds that facilitate the information problem solving skills and self-regulatory processes leads to statistically significant higher knowledge performances on the posttest compared to the conditions deprived of teacher-enhanced scaffolding. Moreover, when we questioned to what extent the effectiveness of scaffolding is influenced by students' characteristics, a significant interaction was found between scaffolding condition and prior knowledge level. Although students with high prior knowledge performed equally on the knowledge posttest irrespective of the way they were scaffolded, the performances of students with low prior knowledge significantly differed with regard to scaffolding condition. Students with lower prior knowledge significantly outperform in the condition with teacher-enhanced scaffolds or in combination with technology-enhanced scaffolds in comparison with the condition without teacher-enhanced scaffolds. As a consequent, human interactions with the teacher / human tutor may prove especially important for more disadvantaged students because the teacher can dynamically monitor inquiry processes. On the other hand, it seems that more advantaged students are able to perform successfully regardless of the scaffolding condition.

These findings are consistent with previous research that stressed that particularly students with insufficient prior knowledge can suffer from minimal guidance from the instructors (Kirschner, Sweller & Clark, 2006). Moreover, Kim & Hannafin (2011) have suggested that especially learners who lack adequate prior knowledge need a teacher or human tutor who can scaffold or model information problem solving.

With regard to metacognitive awareness and self-reported strategy use, however, technology-enhanced scaffolding seem to be more beneficially. The technology-enhanced scaffolding embedded in the web-based project constantly prompted students to perform regulation during web inquiry. Only providing students with these fixed scaffolds is as effective as the combined condition with regard to regulation of cognition. No significant interactions with students' characteristics were found. Providing students with teacher-enhanced scaffolds but without incorporation of the embedded prompts, however, ends in significantly lower results.

In this respect, our findings leads us to believe that to adequately support web-based inquiry learning, which aimed at knowledge construction as well at improving information problem skills, multiple modes of scaffolding are needed. Subsequently, our results support the notion of multiple, distributed scaffolding (McNeill & Krajcik, 2009; Puntambekar & Kolodner, 2005; Tabak, 2004) as an approach to enhance students' inquiry in complex classroom environments. Multiple scaffolding gives teachers the opportunity to differentiate between students with different gender and prior knowledge level. Moreover, this study provided new insight in ways to improve learning environments and scaffolding in order to reduce gaps between learners.

## Output

- Raes, A., Schellens, T., De Wever, B., Vanderhoven, E. (2011). *Multiple modes of scaffolding to enhance web-based collaborative inquiry learning*. Paper accepted to present at the CSCL conference, Hong Kong.
- Raes, A., Schellens, T., De Wever, B., Vanderhoven, E. (under review). *Scaffolding Information Problem Solving in Web-based Collaborative Inquiry Learning*. Computers & Education.

## Third Research Cycle: Work in Progress (2010-2011)

In previous studies, collaboration was integral and consistent to the research design and approach. Yet, so far most statistical analysis (pre-post-comparisons) are conducted on an individual level. 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 will pay more attention to the collaboration processes multilevel analysis will be applied. During the third study, we are planning to study how scaffolding with an external collaboration scripts can be designed to have synergistic effects within the existing context.

Preliminary results will be available by June 2011 and will be interesting input for the discussion at the consortium about scaffolding collaborative inquiry and Information Problem Solving.

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## Can “Prominence” and “Aggression” Enhance Learning?

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**Abstract:** Collaborative learners have to perceive, elaborate, and share relevant information in order to build knowledge. To support these processes, and therefore enhance the outcome of knowledge building, I adopt the communication scientific news value theory. This theory is about the value of news, expressed by particular characteristics, so called news factors. Research has shown that news factors influence all three of the above processes. Journalists perceive and elaborate certain information influenced by news factors and by ascribing news factors to information they decide to share some of them. A pilot study showed that laypeople also do identify news factors accurately. To enhance learning with news value I make use of microblogging systems, such as Twitter, because within microblogging systems processes of perceiving, elaborating, and sharing are dominant. An empirical research program using systematically prepared material will investigate how news factors influence perception, elaboration, and sharing of information.

### Research Goals

For people who want to form an opinion or even just want to know what is currently going on about a topic of interest it is difficult to get an overview about that particular topic that includes as many perspectives as possible. Among the reasons for this difficulty are the frequency of incoming news and the variety of news media and sources. Collaborative learners are also confronted with a similar challenge as they have to combine different perspectives, collect information, and compare sources in order to build knowledge. This dissertation project investigates if and how processes of perceiving, elaborating, and sharing of relevant information could be supported in a beneficial way in general for persons who seek to form an opinion as well as for collaborative learners. I focus on particular characteristics of information, adopted from the communication scientific news value theory that addresses the value of news (Galtung & Ruge, 1965; Lippmann, 1922). These characteristics that describe the news value are called news factors. I argue that news factors can help to structure information, make differences in its presentation salient and can therefore enhance elaboration and learning outcome.

Results of my pilot study indicate that laypeople are able to identify news factors quite accurately. Thus, an aim in the next study is to find out which news factors stimulate the sharing and the elaboration processes. As research about group awareness and social navigation has shown that feedback about other users' behavior can have a beneficial influence on the navigational behavior of users (Buder, Bodemer, Dehler, & Engelmann, 2009) I propose to combine these findings with the potential of the news value theory. Therefore, based on the results of the first studies, I plan to develop a group awareness tool that will help learners to enhance their learning outcome. Such an awareness tool could filter and present similar pieces of information about the same topic that was rated with different news factors by other users. Such a presented conflict should therefore stimulate the elaboration of the information, and create the opportunity for a profound and unbiased formation of an opinion.

### Theoretical Background

Opinion formation requires a specific kind of information processing as people not only have to perceive information from a huge amount of incoming news. They also have to elaborate that information they regard as relevant. Finally, people compare and spread news by talking about them. Thus, and to enhance clarity, the triad of perception, elaboration, and sharing of information I will refer to in the following as information processing. I believe that the above described three processes are also part of the information processing collaborative learners do to build knowledge. In contrast to conventional, teacher-centered learning, collaborative learning is more than just reception and acquisition of knowledge that is presented by a teacher or expert. It is learner-centered and involves knowledge building (Scardamalia & Bereiter, 2006; Stahl, Koschmann, & Suthers, 2006). The first process is to perceive particular pieces of information from a large pool of information. The second process is to elaborate the perceived pieces of information. The third process is to share some of it with others to create common knowledge artifacts. Therefore, my research about information processing for opinion formation might contribute to collaborative learning. One conceptual approach that might not only help to analyze but even to enhance information processing is to draw on communication science which offers several theories about production, selection, and perception of information. One theory, among others, is the news value theory (Galtung & Ruge, 1965; Lippmann, 1922) that asks for and describes the value of news. An appropriate way to adopt this theory in order to investigate and enhance information processing is to use microblogging systems such as Twitter. Microblogging systems as typical Web 2.0 applications are networks for writing and sharing

short pieces of information, which are usually not longer than 140 characters. Users can read the information of those users they have subscribed to. A commonly used feature of microblogging systems allows users to share information by simply forwarding it to others. This feature is interesting to me, as the process of sharing information is reduced to basic mechanisms of information spreading, and does not involve additional elements of knowledge creation. That means content can be produced even without writing new messages, thereby increasing experimental systematicity and tractability. Moreover, the simplified sharing mechanism is interesting, as it might help to uncover processes of viral distribution of content. Zarrella (2009) has shown that it is not daily chatter that is forwarded mostly in Twitter, but news. As real time news media (Kwak, Lee, Park, & Moon, 2010) microblogging systems offer the potential of nearly unlimited spread of information. Users therefore have to deal with a huge amount of information and process information that is in some way interesting for them or others to form an opinion. This is exactly what collaborative learners are also often confronted with to build knowledge. My research builds on the news value theory because it addresses information processing in the news media context. I propose to transfer the news value theory to the learning context in which news value could enhance the learning outcome of knowledge building and opinion formation.

News value theory is about the value of news (Lippmann, 1922) and the selection criteria that make events become news. From all the events taking place around the world every day 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 (for examples see Table 1) 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. News value theory is well investigated from the perspective of journalists and news production (e.g. Eilders, 2006; Kepplinger & Ehmig, 2006). Interestingly, 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 (1997) found that news factors also affect the *elaboration* of information as measured by memory performance. Transferred to Web 2.0 and microblogging systems, the circle is complete as the recipient easily changes role to a producer and *shares* the information again by publishing or forwarding. To sum up, news factors might affect all the three components of the information processing triad. These processes are also central for collaborative learning.

Galtung and Ruge (1965) identified a set of news factors that has been extended by several researchers. A recent adaption has been performed by Ruhrmann and Göbbel (2007). They proposed a set of news factors that I adopt for my research (see Table 1).

Table 1: News factors and their meanings (cf. Ruhrmann & Göbbel, 2007; translation by the author).

<b>News factor</b>	<b>Meaning</b>
Relevance	Number of people who were/are/will or could be directly affected by an event or a development
Proximity	Geographical distance; political, economical or cultural similarity
Prominence	Popularity of the person mentioned, regardless of his or her actual political/economical power
Personalization	Individuals get a special meaning within an event; if one person or a few people are illustrated or even portrayed representatively for a group or a company
Aggression	Threatened or practiced violence
Negative consequences	The negative consequences of events are mentioned explicitly in the message
Controversy	Explicit presentation of differences of opinions
Unexpectedness	An event that cannot be predicted or stands in contrast to existing expectations
Continuity	The duration for which news media has been reporting on the topic
High status	Economical, political, and military importance of nations; results from military power, gross national product, and external trade

Although research of news value theory already addressed information processing, there is not yet research using carefully manipulated material with systematically varied news factors. Such controlled conditions would allow me to investigate the possible influence of news factors on information processing. Furthermore, using Twitter not only moves the news value theory away from classical media production, but also situates research questions in the context of Web 2.0 and collaborative learning. To my knowledge, no research has been done to connect perception, elaboration, and sharing in this particular context until now.

In the following, the news value theory and news factors are discussed with respect to some underlying psychological concepts to better understand and predict their possible effects on information processing. To start with, several news factors are based on the feeling of potentially being involved or affected. For example, this is true for “Relevance” or “Proximity”. The more people are affected or the closer an event happens, the more likely it is for people to get involved, too. Other news factors, for example “Personalization” or “Prominence”,

refer to processes of identification or role-taking (van Dijk, 1988). Sensational, negative or aggressive news benefits from the evolutionary tendency to pay attention to unknown or sensational things, because they might be dangerous (Davis & McLeod, 2003). Research has shown that negative news in general receives higher attention because the human brain has an automatic attentive response to negatively compelling stimuli (Grabe & Kamhawi, 2006). This would be the case for news including “Aggression” or “Negative consequences”. “Controversy” can stimulate creativity as it presents conflicting positions or views, and could also gain attention because, in case it is a political controversy, it could indicate an important result for the 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, the news factor “Continuity” can influence information related processes because people prefer familiar stimuli. The concept of availability heuristic (Tversky & Kahneman, 1973) refers to such familiar stimuli and might attract attention quickly also to news about Prominence or high status nations (“Status”).

Some news factors might be identifiable more easily than others. The difference could be the degree of elaboration required to assess the factors. Most people do not have difficulties to identify a prominent person, especially not if the message is short and a popular name is mentioned (“Prominence”). Also for “Aggression”, people can indicate specific words surely referring to violence, for example “brutal”, “murder” or “assault”.

These concepts can help understand how people react to particular pieces of information. 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, described and varied by news factors. Information can be structured more clearly and so users could get a better overview about the presented pieces of information. Therefore, news factors can be seen as a way to filter information to influence users’ behavior. I 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 feedback of other users’ behavior can influence the navigational behavior of users (Buder, Bodemer, Dehler, & Engelmann, 2009) and leads to better decisions and learning outcomes. Hence, combining the potential influence of news factors on information processing with the principle of group awareness and social navigation can support learners to enhance their learning outcome.

In the following, I introduce my empirical research program that will consist of a pilot study and further experimental studies. These are based on the results of the pilot study that indicated that news readers are able to identify news factors quite accurately.

## Methodology

I plan an empirical research program that first explores identification abilities of news factors, and second investigates sharing principles and elaboration processes of information in combination with news factors. Experimental studies will show whether news factors improve the information processing. Further, I would like to investigate experimentally how a group awareness tool could additionally enhance information seeking and opinion formation.

At first, an already conducted exploratory study proved if news factors are actually generally valid criteria (Eilders, 1997), that means whether recipients without specific knowledge about news value theory 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,  $SD = 5.55$ ). I created the presented material together with early career scientists having a degree in communication science who were all familiar with the news value theory. We created a set of 63 short messages about a wide range of topics. We prepared the messages so that each of them implied particular news factors. I used a subset of the set of news factors proposed by Ruhrmann and Göbbel (2007; see Table 1). These underlying news factors of the created material were uncorrelated and balanced in their occurrence. The communication scientists rated the information for each news factor as 0 vs. 1 (“news factor does not fit” versus “news factor fits”). Based on the experts’ ratings a distinct ascription could be made for each message to compare it with the participants’ ratings.

For the study the participants received a short description of news factors, and were subsequently asked to rate all messages according to their news values.

## Preliminary Results

To measure the agreement between the scientists’ and the participants’ ratings I refer to the signal detection theory and used the sensitivity index  $d'$ . Signal detection theory does not only regard the hits (people ascribed a news factor that was also ascribed by the communication scientists) but does also consider the false alarms (people ascribed a news factor that was not ascribed by the communication scientists). Thus, signal detection theory is an appropriate way to measure the performance of identification of the news factors. The results indicate that average people identify news factors quite well (see Table 2). Referring to Green and Swets (1966), higher values mean higher sensitivity. Another factor indicated by the hit rates and the false alarm rates is the

response bias. The response bias is the general tendency to respond yes or no, as determined by the location of the criterion.

As suggested, sensitivity is high especially for news factors that are easily identifiable, for example when referring to a cue word, for example a name for “Prominence” or a violence indicating word like “brutal” for “Aggression”. 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). Most of the news factors were rated conservatively what indicates that participants clearly recognized if those news factors have been absent. These findings are a first important step towards an investigation using carefully manipulated material with systematically varied news factors. As far as I know, this had not been done before.

Table 2: 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

## Current Status

Preliminary theory work is finished and after having analyzed the data of the first exploratory study I am about to plan the second study which will focus on the sharing process of information. There, I additionally will compare different kinds of rating (rating on news factors vs. rating on source credibility) regarding learning. I expect information rated on news factors is more likely to be highly elaborated because this rating is about content. In contrast, I expect information rated on source credibility is more likely to be lowly elaborated because this rating should be based on a heuristic cue (Petty, Heesacker, & Hughes, 1997). Thus, I expect a better memory performance for the information rated on news factors than for information rated on source credibility. The data collection for the second study is scheduled for May 2011.

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## Collaborative Learning with Multiple Representations in a Computer-Based Setting

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**Abstract:** The benefits of learning with more than one representation have been broadly recognized in educational psychology (Ainsworth, 2006) and mathematics education (Cuoco & Curcio, 2001), but these benefits do not unfold automatically. One possible approach to promoting learning with multiple representations is to integrate collaborative learning (Rummel & Braun, 2009). Interesting findings on collaborative learning with multiple representations have been presented by the work on productive failure (Kapur, 2009). This work suggests that students can profit from generating multiple representations during collaborative problem-solving prior to instruction. Building on the work on productive failure and on the literature on collaborative learning, we are conducting two studies to answer the following questions: What type of support do students need when they learn with self-generated representations in small groups? Is it more beneficial for learning when students generate representations themselves or when representations are externally provided to the students?

### Goals of the Research

The curricular standards of the German federal states emphasize the goal of teaching mathematical reasoning (KMK, 2003), which requires the understanding and application of different representational formats (e.g. tables, graphs, and algebraic notations). Our project aims to investigate learning with multiple representations in a collaborative setting as a way to support students' ability to reason mathematically (KMK, 2003), also known as mathematical literacy (OECD, n.d.). Mathematical literacy comprises the understanding of mathematical concepts and problem-solving procedures as well as representational competency. In this context, representational competency comprises an understanding of different representational formats and the ability to translate a given representation into another format (Vollrath, 1989). The benefits of learning with more than one representation have been broadly recognized in mathematics education (e.g. Cuoco & Curcio, 2001) and educational psychology (e.g. Ainsworth, 2006). However, research has also shown that these benefits do not unfold automatically (e.g. Ainsworth, 1999). One possible approach to promoting learning with multiple representations is to include collaborative learning opportunities (Rummel & Braun, 2009). Interesting findings on collaborative learning with multiple representations in mathematics have been presented by the work on productive failure (e.g. Kapur, 2009). This work suggests that students can learn from multiple representations that they generate during collaborative problem-solving prior to instruction. Our project targets the question how to implement collaborative learning with multiple representations. More specifically, building on the work on productive failure and on the broad literature on collaborative learning, the following questions are investigated: What type of support do students need when they learn with self-generated representations in small groups? Is it more beneficial for learning when students generate representations themselves or when representations are externally provided to the students?

### Background of the Project

The mathematics education literature points at the importance of developing an understanding of representational formats and their interrelations (e.g. tables, graphs, and algebraic notations) as a prerequisite for communicating about and reasoning with mathematics (e.g. Cuoco & Curcio, 2001). Teaching students to understand and connect different representational formats not only improves their representational competency, but also fosters their understanding of the underlying mathematical concepts and problem-solving procedures. These assumptions are in line with the benefits of learning with multiple representations found in educational psychology research (e.g. Ainsworth, 2006). Most work on learning with multiple representations in educational psychology research has been done in computer-based environments. Digital media provide opportunities to present multiple representations with interactive features. These interactive features may facilitate handling several representational formats. While the potential benefits of learning with multiple representations have been broadly recognized (especially in computer-based environments), several studies demonstrated that students do not automatically benefit from multiple representations. One problem that has been identified is that students often tend to treat the representations in isolation instead of making connections and integrating the information provided by the different representations (e.g. Ainsworth, 1999, 2006).

One possible approach to promoting learning with multiple representations, and particularly to promoting connection-making across representations, might be to include collaborative learning opportunities (Rummel & Braun, 2009). Within a small group, members may have different perspectives on the

representations. By discussing and elaborating the different perspectives and representations a deeper processing of the underlying concepts and features of the representational formats may be fostered. This deeper processing may facilitate connection-making across representations. Indeed, research on collaborative learning in computer-based environments that include multiple representations shows that students discuss and explore connections across different representations (e.g. Suthers & Hundhausen, 2003). Very recent work by Weinberger and Gijlers (2010) proposes to use tablet PCs for collaborative learning with multiple representations as these tools offer high flexibility when handling and editing multiple representations in small groups. Similar to the environment used in the study by Suthers and Hundhausen (2003), many collaborative learning environments include multiple representations; however, research has usually focused on the question of how to support collaboration with the help of multiple representations, and rarely the other way around. Hence, it remains to be investigated how collaboration can support students in learning with multiple representations and how to design collaborative settings for learning with multiple representations.

Based on the way mathematics textbooks and courses are most commonly designed, collaborative learning with multiple representations would normally be implemented in the following way: The textbook or the teacher gives an introduction to a new mathematical topic by using different representational formats, for example, symbolic representations, such as formulas, and graphical representations, such as diagrams. Afterwards students practice problem-solving using these representational formats in small groups. An alternative approach would be to start by having students interact with multiple representations in a self-regulated fashion before the teacher provides instruction. In other words, students would first generate and/or learn with multiple representations in small groups in order to develop an intuitive understanding of the targeted mathematical content and only afterwards the teacher would provide instruction building on these representations. In this alternative approach to teaching mathematical concepts with multiple representations, the teacher-led instruction and support are delayed. This approach is taken in the *invention paradigm* put forward by Schwartz and colleagues (e.g. Schwartz & Martin, 2004) as well as in the *productive failure paradigm* by Kapur and colleagues (e.g. Kapur, 2009). In a series of experiment conducted by Kapur and colleagues in Singaporean classrooms, students in the productive failure condition engaged in problem-solving activities in small groups without receiving instructional support. Process data showed that during this problem-solving phase students collaboratively generated and discussed a diversity of representations. Thereafter, the teacher provided instruction in a consolidation phase, that is, the student-generated representations were compared and contrasted in a teacher-led discussion which finally led to the presentation of the canonical solution by the teacher. Although students in the productive failure condition were rarely able to find the correct solution during the problem-solving phase, they significantly outperformed students of a direct instruction condition in the post test, that is, they learned more (e.g. Kapur, 2009). However, so far the relevant cognitive and collaborative processes during students' activities with the representations remain unclear. Thus, when implementing collaborative learning with multiple representations in a student-regulated fashion, further questions remain to be answered: The first question to be answered would be what kind of support students need when collaborating with the representations. While advocates of the invention paradigm and of the productive failure paradigm argue for a delay of instruction and support structures, the broader background of the literature on collaborative learning suggest to support students' activities at least to some extent as productive collaboration does not occur automatically (O'Donnell, 1999). It can be assumed that in the context of learning with multiple representations the benefits of collaborative activities also unfold best when some support is given (Rummel & Westermann, 2010). Based on this assumption it seems that the line between productive failure and unproductive failure, as defined by Kapur and Rummel (2009), may be crossed if absolutely no support is given while students are engaging with multiple representations in small groups. It therefore seems to be a logic first step to investigate what type of support students need when they collaboratively learn with multiple representations. A second question to be investigated towards understanding the mechanism of a successful implementation of collaborative learning with multiple representations would be whether it is more beneficial for learning when students generate representations themselves or when representations are externally provided to the students. In research on learning with multiple representations the representations are usually externally provided to the students (e.g. Ainsworth, 1999), whereas within the productive failure paradigm students self-generate representations (e.g. Kapur, 2009). Based on the concept of representational determinism (Zhang, 1997), different cognitive processes can be expected when learning with self-generated or with externally provided representations (Cox, 1999). Therefore it seems promising to investigate the processes and learning outcomes resulting from learning with self-generated representations compared to learning with representations that are externally provided to students.

## Methodology

Two experiments will be conducted to investigate questions concerning collaborative learning with multiple representations: The first experiment focuses on collaborative learning with self-generated representations. We will investigate experimentally what type of support students need when they collaboratively learn with self-generated representations. In addition, we will conduct in-depth analyses of the processes of learning with self-generated representations. Based on the results of this study we will conduct a second experiment focusing on the different impact on learning of self-generated representation as opposed to representations that are externally provided to the students.

In the *first experiment*, which we are currently conducting, we aim to shed light on the support features necessary for a productive failure setting to lead to productive interactions and learning. During a problem-solving phase, students are instructed to try different solution approaches by generating different representations, such as tables, graphs and formulas. Students work in groups of three. They use tablet PCs to generate and exchange representations. The use of tablet PCs allows student to work individually as well as to share their ideas and focus the group's attention on selected representations. The problem-solving phase is followed by a consolidation phase where the teacher introduces the canonical solution by building on the generated representations. In earlier studies on productive failure (Kapur, 2009), students received only motivational support to persist in generating different representations during the unsupported problem-solving phase. In current studies by Kapur (personal communication, March 2010), students are additionally prompted to critically reflect about the representations they generated in order to improve their solution approach from one representation to the next. Thus, their cognitive engagement with the representations is supported. The differences between the support features in the former and the latter studies have not been investigated empirically so far. To close this empirical gap, we compare these two conditions by varying the support types during the collaborative problem-solving phase as shown in table 1: Students in the *standard productive failure condition* (PF) receive motivational prompts encouraging them to persist in solving the task (e.g. "it is okay to struggle with the problem"; "you are doing a good job together"). In the *augmented productive failure condition* (PF+), students additionally receive cognitive prompts, that is, students are supported in their critical evaluation of the representations they generate (e.g. "maybe there are situation where your solution does not work, have a look at this counter-example"). Parallel to Kapur's studies, in addition to the two productive failure conditions, we implement a *direct instruction condition* (DI) that serves as a control condition. In the direct instruction condition the teacher explains the concept and introduces the canonical solution by using different representational formats, before the students solve practice problems in small groups.

Learning outcomes are assessed by an intermediate test after the problem-solving phase and by a posttest after the consolidation phase to measure the effects of both phases separately. The posttest includes retention items, conceptual items that test for deeper understanding, and transfer items. In addition, we implement a one-week delayed posttest. Participants are 10<sup>th</sup> graders recruited from two secondary schools in Bochum, Germany. The learning material used in the productive failure studies in Singapore has been translated and adapted to the German curriculum. Subsequently the material was adjusted for each condition respectively.

As argued above, collaborative self-regulated engagement with multiple representations prior to instruction may help students to make connections across different representations and thereby may foster the understanding of mathematical concepts and of the representational formats. However, based on the literature on collaborative learning, the potential benefits of collaborative self-regulated engagement with the representations do not unfold automatically and therefore the PF condition without cognitive support may cross the line between productive failure and unproductive failure. We hypothesize that the combined support in the PF+ condition best supports students in structuring and developing their ideas and thereby will lead to better learning outcomes compared to the PF condition and the DI condition, whereas the PF condition may or may not outperform the DI condition. The results of the study will be presented and discussed in the doctoral consortium workshop.

Our general hypothesis is that in the context of learning with multiple representations collaboration may lead to better learning. This hypothesis is based on the assumption that students in small groups share and discuss their different perspectives on the task at hand, and that in the problem-solving process students are likely to make connections across the different representations that they generate. However, this assumption has to be tested in in-depth process analyses. Therefore we record process data of students' interactions. The process data recorded with the tablet PCs, and video and audio recordings will enable a detailed analysis of how students generate representations individually and in the group, whether they make connections across them, and how those processes might differ between the experimental conditions we implement. The results of the first experiment will enable us to generate more specific hypotheses concerning the differences between learning with self-generated representations and learning with externally provided representations than can be done based on the present literature. These hypotheses will be investigated in the second experiment.

Table 1: Conditions of the first experiment.

	<i>Learning phase 1</i>	<i>Learning phase 2</i>
<i>PF</i>	Problem-solving in small groups with motivational prompts	Teacher-led compare and contrast, presentation of the canonical solution
<i>PF+</i>	Problem-solving in small groups with motivational and cognitive prompts	Teacher-led compare and contrast, presentation of the canonical solution
<i>DI</i>	Instruction and presentation of the canonical solution	Problem-solving in small groups

In the *second experiment*, which will be conducted in the fall of 2011, we will investigate the differential effects of learning with self-generated representations as compared to learning with externally provided (non-canonical) representations in order to address the following questions: Do students have to generate their own representations, or would learning with representations that are externally-provided to the students be sufficient to promote learning? Is it beneficial for learning when students first learn with representations in a self-regulated fashion or would it be sufficient or even better for their learning, if the teacher first compares and contrasts different non-canonical representations (as they are typically generated by students) in a classroom discussion? In order to answer these questions, we will experimentally compare three conditions as shown in table 2: In a regular *productive failure condition* (PF; based on the results of the first study), students collaboratively generate representations that they compare and learn with. In a *study and compare condition* (S&C), students will be given multiple representations that they are asked to study and compare; however, they will not generate their own representations. The representations provided to the students will be taken from those generated by students in the first study (i.e. they will receive non-canonical representations that students usually generate in a productive failure condition). In a *teacher-led control condition* (Teacher), the teacher will compare and contrast the same non-canonical representations given to students in the S&C condition before presenting the canonical solution. Students will then practice problem-solving in small groups.

In line with the findings concerning students' difficulties in making connections across multiple representations (e.g. Ainsworth, 1999), we are inclined to hypothesize that it is more conducive for students to learn with self-generated representations than with externally provided representations. Students identify with their self-generated representations which may lead to a higher task engagement (diSessa, Hammer, Sherin & Kolpakowski, 1991). From a cognitive load perspective (Paas, Tuovinen, Tabbers & Van Gerven, 2003), it may be easier for students to handle their own representations than externally-provided representations: Students must fully understand each representation before they can make connection across them in a meaningful way. After students have self-generated a representation, the process of understanding this representation should be completed and thus, the cognitive capacity should be free for making connections. The hypotheses for the second experiment will be refined based on the results of the first experiment.

Table 2: Conditions of the second experiment.

	<i>Learning phase 1</i>	<i>Learning phase 2</i>
<i>PF</i>	Problem-solving in small groups	Teacher-led compare and contrast, presentation of the canonical solution
<i>S&amp;C</i>	Studying and comparing non-canonical representations in small groups	Teacher-led compare and contrast, presentation of the canonical solution
<i>Teacher</i>	Teacher-led compare and contrast of non-canonical representations, presentation of the canonical solution	Problem-solving in small groups

Overall, the project will provide insights into the benefits and processes of collaborative learning with multiple representations. As it is still unclear how to best support students' in making connection across multiple representations, the findings of this project may help to optimize the design of collaborative learning environments with multiple representations that foster a fruitful learning process to improve both, students' mathematical competencies as well as their representational competencies. Both competencies are important for students' ability to reason mathematically and thus, an improvement of these competencies will help to meet the curricular standards of the German federal states (KMK, 2003).

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# The Diffusion and Implementation of Learning Management Systems in Higher Education

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**Abstract:** The purpose of this dissertation is to examine the diffusion and use of a specific class of technologies—learning management systems (LMSs)—to better understand the multiple factors affecting the implementation of learning technologies in higher education. Given their penetration across colleges and universities, LMSs offer a compelling case that can be used to advance theory and bring together practical insights concerning the adoption of learning technologies in educational settings.

## Goals and Background

As universities work to keep up-to-date with technological advances, they simultaneously face the demands of decreasing budgets and increasing calls for instructional accountability (Arroway & Sharma, 2009). Each of these demands, as well as society's shifting expectations for higher education, can play a significant role in shaping a college or university's decision to adopt a technological system (Trow, 1997), especially when those technological systems are aimed at improving teaching and learning (Adams, 2002; Owen & Demb, 2004; Privateer, 1999). The purpose of this dissertation is to examine the diffusion and use of a specific class of technologies—learning management systems (LMSs)—to better understand the multiple factors affecting the implementation of learning technologies in higher education. To achieve this general aim, this dissertation explores the following research questions:

1. How did various actors—in popular and academic texts—describe and justify the use of LMSs in higher education?
  - a. In what ways did actors' descriptions and justifications shift over time?
2. What events were occurring at one university that supported or hindered the implementation of an LMS?
  - a. How did university administrators describe and justify the need to implement an LMS?
3. What are the dominant patterns in LMS use by instructors across an entire university?
  - a. In what ways have these patterns changed over time?

Each of the above research questions is aligned to a specific level of analysis: institutional (RQ #1), organizational (RQ #2), and instructional (RQ #3). While each of these levels is conceptually distinct, in practice, they reciprocally affect one another through complex interactions extending over time (Barley, 1986; Orlikowski, 2000). Thus, an important aim of this dissertation is to explore the degree to which classroom instruction, and specifically—technology use—is influenced by broader institutional and organizational pressures.

The outcomes of this dissertation are intended to help researchers, policy makers, and practitioners glean lessons related to the diffusion and implementation of a widely used learning technology. LMSs are a class of technologies that support a wide range of functionalities, such as posting assignments, managing grades, creating a course blog or wiki, and exchanging digital resources—all within a comprehensive online environment. These systems are one of the few technologies, specifically designed to enhance teaching and learning, that have achieved wide-scale use in educational settings. LMSs are used across more than 95% of colleges and universities in the United States (Smith, Salaway, & Caruso, 2009); given their penetration across higher education institutions, LMSs offer a compelling case that can be used to advance theory and bring together practical insights concerning the use and implementation of learning technologies in educational settings. Though widely diffused, how and why LMSs were able to achieve such wide-scale use remains largely unexplored.

Focusing on the diffusion and implementation of a specific technology affords an in-depth examination of the complex interactions among technologies, organizations, and institutions, by which multiple disciplines are increasingly focused on developing more sophisticated frameworks for understanding these complex interactions. Beyond intended theoretical contributions, the diffusion and implementation of LMSs touches on several pressing concerns in higher education, for example, copyright and intellectual property related to course materials, online learning opportunities provided by universities, and the increasing costs of technology support for colleges and universities.

## Theoretical Framework

The theoretical framework for this dissertation addresses the role of rhetoric in the diffusion and institutionalization of innovations as well as factors affecting the enactment of instructional innovations. Specifically, this theoretical framework focuses on two themes: first, how the rhetoric accompanying a diffusing

innovation can propel or hinder its implementation (Green, 2004), and second, how adopters—both individuals and organizations—can adhere to a variety of different logics in their adoption and eventual use of an innovation (Strang & Meyer, 1993). A consistent finding from research on LMSs is that instructors typically use these systems in ways that promote a traditional, “transmission” model of instruction, which is typified by uses that promote the efficient management and dissemination of course-related materials (Lonn & Teasley, 2009; Morgan, 2003; Papastergiou, 2006). Explanations for this model of LMS-use often address the design of LMSs as promoting instructor-centered pedagogies (Dutton, Cheong, & Park, 2004) or a lack of training received by university instructors in how to use these systems (Lane, 2009). While each of these explanations highlights an important facet of a complex issue, each tends to ignore broader influences, such as institutionalized notions of instruction in higher education (Meyer & Rowan, 1977), the effects of discourse in legitimizing certain innovations over others (Green, 2004), or the relative importance of teaching in the promotion and tenure process at most universities (Cuban, 2001). Thus, to better understand how LMSs have come to be used in university classrooms, as well as how and why they diffused across colleges and universities more generally, requires careful attention to numerous institutional and organizational factors (see Cohen, 1987; Cohen & Ball, 2007; Cuban, 1986; Tyack & Tobin, 1994 for a similar argument related to generic instructional innovations).

The diffusion of innovations can be understood from the perspective of the innovation, innovators, adopters, or the contexts in which innovations are adopted and diffused (Rogers, 2003). A focus on discourse captures the ways in which innovations are social constructions whose meaning extends beyond its physical components (Bijker, Hughes, & Pinch, 1987). Critical to understanding diffusion in K-12 and higher education—and the diffusion of information technologies more generally (King et al., 1994)—is the highly institutionalized quality of organizational life (Strang & Meyer, 1993). As Strang and Meyer argue, institutionalized aspects of organizational life make diffusion possible where more direct communication channels, such as in Rogers’ (2003) models of diffusion, are not apparent. From a generic institutional perspective, adoption of new practices is premised on alignment with normative expectations for the organization that persist in the wider society, what Meyer and Rowan (1977) refer to as conforming to rationalized myths. Thus, organizations do not adopt innovations solely in the interest of efficiency gains; innovations are often adopted under different logics, such as appeasement or legitimacy concerns (DiMaggio & Powell, 1991). Organizations situated within highly institutionalized fields, such as colleges and universities, are often impelled through normative, regulative, or cultural means to align their activities with institutionalized expectations for their processes and products, such as when adopting technological systems (Scott, 2008). Thus, diffusion, like many organizational activities, is subject to a variety of different logics that can lead to the adoption of “inefficient” innovations and the rejection of “efficient” ones (Abrahamson, 1991).

A possible conclusion of diffusion is institutionalization, which is the degree to which an innovation assumes a level of taken-for-grantedness (Jepperson, 1991), or has been imbued with meaning beyond the perceived technical efficiencies of the innovation (Selznick, 1957). Often what cements an innovation’s taken-for-grantedness is the plausibility of justifications applied to an innovation at key points in its diffusion (Czarniawska, 2008). Diffusion and institutionalization are related, yet, not identical processes in that an innovation may be widely diffused but not taken for granted. What distinguishes diffusion from institutionalization is the degree to which an innovation requires continual sensemaking, which indicates that the justifications ascribed to the innovation are in flux, thus impeding a diffusing innovation’s ability to be taken for granted as a social fact (Weber & Glynn, 2006). The need to justify an innovation’s adoption shifts over time, where early on, more intense discussion should occur around an innovation. For example, the role of rhetoric in the early stages of diffusion is one of “sharpening beliefs that the new practices solve recurring practical problems” (Green, 2004, p. 658).

Several macro models of diffusion argue that prior adoption of an innovation can propel it forward across different diffusion groups through mechanisms, such as increasing returns (Arthur, 1994) or institutional isomorphism (DiMaggio & Powell, 1983). By focusing on discourse, these macro-level mechanisms can be grounded in micro-level interpretations made by actors interacting with an innovation, interactions that involve “the development of some degree of social consensus among organizational decision-makers concerning the value of a structure, and the increasing adoption by organizations on the basis of that consensus” (Tolbert & Zucker, 1996, p. 182). Important to this consensus building are the ways in which an innovation is framed, in the media and through social interactions, in terms of what problems the innovation can be thought to solve (Benford & Snow, 2000). For the purposes of this study, highlighting the interpretive work that goes into the diffusion of technologies is an attempt to make explicit that the diffusion of technologies is often propelled (or hindered) in line with complex discursive practices (Orlikowski & Gash, 1994).



## Methodology

### Research Question #1

To examine factors affecting the diffusion of LMSs throughout higher education, I searched both academic and nonacademic texts and examined the following themes: (1) the benefits and drawbacks cited for adopting an LMS, (2) problems in higher education for which LMSs were deemed plausible solutions, and (3) overarching social / technological changes used to justify LMS adoption. To collect academic texts, I searched the ERIC CSA database. For nonacademic texts, I searched two well-known sources: *The Chronicle of Higher Education* and EDUCAUSE publications. EDUCAUSE publications represent a middle ground between peer-reviewed academic texts and non-peer reviewed texts. Upon identifying pertinent articles, I coded aspects of each text related to LMSs as well as historical trends related to the diffusion of LMSs. Across both academic and nonacademic texts, I tracked individuals, dates, institutions, and roles of individuals making statements related to LMSs. Date of publication were used to assess whether or not the discourse accompanying the diffusion of LMSs shifted over time.

### Research Question #2

To capture the events that were unfolding during the adoption of an LMS at one university, I examined two sources of data. The first source data were semi-structured interviews with key academic administrators, faculty, and staff involved in the adoption of an LMS. Through these interviews, I identified factors that influenced their decisions to adopt an LMS, their perceptions on how LMSs were to improve instruction in university classrooms, and their appraisals of how technological changes on campus influenced the adoptions of an LMS. The second source of data that I analyzed included archival data related to the adoption of one LMS as chronicled in the university's historical archives. Archival data was content analyzed to develop a chronological list of events that were germane to the implementation of the LMS. Example events include changes to the university's information technology governance structure and changes related to the technology infrastructure on campus.

### Research Question #3

To examine the use of LMSs in higher education classrooms, I investigated actual usage of an LMS throughout an entire university. For this analysis, I examined system log data that tracks instructors and students' use of the LMS extending over six academic semesters at one university. Using system log data, I constructed "course complexity" scores. To construct these scores, I used 2-parameter item response theory (IRT) scaling procedures (Embretson & Reise, 2000). The benefit of using two-parameter IRT models is that they can account for the proportion of courses activating a collection of LMS tools and differentiate among courses that activate different combinations of tools. These scores were used to identify the LMS tools activated by instructors and to provide a single metric for describing the degree to which instructors' use of the system changed over time.

## Current Status and Preliminary Results

The current status of my research is as follows. I collected approximately 1,100 academic and non-academic texts pertaining to learning management systems (RQ #1). These texts span a 20-year publication period between 1990 and 2010. Along with full-text versions of available articles, I downloaded abstracts for all texts that were deemed relevant to my search terms. I used these abstracts to construct an initial database. This database includes multiple features, such as publication type, date, author, and title, along with codes inductively generated from full text of versions of each article. Deploying the same search terms, I used the qualitative coding software, Atlas.TI, to locate and highlight each search term within and across full-text versions of each article. This provided an initial way to locate relevant analytic units for coding. Both sentences that contained the keyword and relevant, surrounding sentences were initially used. Along with these fine-grained, sentence-level codes, I identified more global codes for each text, such as the purpose of each article and the overall sentiment of the article toward LMSs. For interview and archival data, I located archives that chronicle such factors as information technology governance at the focal university and identified a sample of 12 individuals who were integral to the adoption of the LMS (RQ #2). For the system log data analyses of this dissertation, I downloaded six semesters worth of data and have used both IRT and hierarchical linear regression analyses to identify dominant patterns in LMS use over this time period as well as multiple factors affecting instructors' enactment of the system (RQ #3).

I identified several trends in both rhetoric and system log data. While preliminary, an important observation to come from analyses of the rhetoric that accompanied the diffusion of LMSs is that these systems are becoming more and more taken for granted across university campuses. For example, in the case of academic articles, there is a slight shift in studying the impacts of LMSs directly to one where LMSs have become integrated into research projects that serve other ends; said differently, instead of being the focus of

research, LMS have become a background infrastructure for supporting multiple research aims. Moreover, discussions of LMSs have begun to show up in a variety of different contexts, such as publications geared toward librarians and a variety of discipline-specific publications. In comparing rhetoric and system log data, I have identified tentative trends whereby the rhetoric accompanying the diffusion of LMSs has had more impact on universities and the organizational field of higher education than it has had in shaping the pedagogical styles of individual instructors.

## Issues to Explore

The particular issues that I would like to explore include identifying alternative analyses for the system log data that I have collected. A majority of my current analyses are focused on using hierarchical linear and logistic regression models. As stated previously, the purpose of analyzing system log data is to track the evolution in types of use across an entire university; therefore, I am interested in using workshop participants' expertise to further clarify the best ways to do this. This may include developing different dependent variables beyond the latent trait scores stemming from IRT procedures that are intended to capture course complexity.

Another issue that I would like to explore with workshop participants is how to efficiently tie together the multiple narratives being developed in this dissertation. I would like to "think aloud" with consortium participants on how to establish further relationships between the rhetoric that is enacted at the organizational field level to the specific instructional uses for the LMS occurring at one university. I am currently working within a neo-institutional theory framework, especially as my dissertation relates to the processes of institutionalization as it occurs across colleges and universities. Therefore, I would like to address the viability of specific theoretical frameworks, such as activity theory or actor-network theory, in developing links between factors affecting the diffusion of LMSs and the ways in which they are used in university classrooms.

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# A Scheme for Analyzing the Development of Knowledge-Building Discourse

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**Abstract:** This dissertation aims to characterize knowledge-building discourse by developing a scheme capable of capturing various discourse moves within the context of interactional dynamics. The scheme provides a new approach for researchers to analyze the developmental trajectory of knowledge building. Multiple data sources are generated from two case studies, comprising 175 students from Science and Chinese classes at Hong Kong schools.

## Goals of the Research

The goal of the dissertation is to characterize the trajectory of knowledge-building dynamics by developing a discourse scheme capable of evaluating the collaborative inquiry process in Knowledge Forum which is a computer-mediated discussion forum for knowledge-building theory (Scardamalia & Bereiter, 2006). The importance of characterizing the knowledge-building trajectory is threefold. First, it is to gain a clear articulation of discourse needed in knowledge building. Second, it is to understand various discourse moves arising in the interactional dynamics that influence and contribute to knowledge building. Third, it is to develop insights for designing effective pedagogical strategies to promote knowledge building in classrooms.

This research aims to answer several research questions. (i) What are the characteristics of students' discourses in Knowledge Forum, with respect to the conceptual framework of knowledge sharing, construction, and creation? For example, what discourse patterns can be found in the empirical data? How student discourse may differ across classrooms and domains? What are productive and debilitating discourse moves? What are the areas in which students may need additional pedagogical supports? (ii) How are discourses in Knowledge Forum created in the social contexts? And how does knowledge building affect student learning? For example, how do teachers develop and design their knowledge-building pedagogies? How knowledge building is implemented in classrooms, especially on the area of scaffolding collaborative inquiry in Knowledge Forum? Whether knowledge building promotes students' domain knowledge and academic achievements in traditional examination?

## Background of the Project

The 21<sup>st</sup> century, known as the knowledge society (e.g. David & Foray, 2002; Drucker, 1994), has been shaped by the pervasiveness of information communication technology, rapid knowledge advancements, and highly competitive globalized economies. A substantial literature on the knowledge society has developed, calling for a new set of skills: they are often known the 21<sup>st</sup> century skills, such as higher-order thinking, problem solving skills, communication skills, information skills, learning skills, and creativity (e.g. Bereiter, 2002; Bindé, 2005; David & Foray, 2002; Hargreaves, 2003). With a goal to develop these ascendent important skills, many learning approaches have been developed in the CSCL, and they are often argued with computer-mediated discussion forum for facilitating collaboration among students.

Knowledge building is one of those approaches in the CSCL, having unique emphases on such things as enabling students to be in control of their own learning, progressive inquiry aimed at idea improvement, a shared goal to advance the collective state of knowledge in a community, and the use of a web-based knowledge space, *Knowledge Forum*®. Instead of advancing individual students' knowledge and skills, students in a knowledge-building classroom collaboratively create and advance their collective knowledge through public discourse in Knowledge Forum. However, sharing a similar problem with other learning approaches in the CSCL about the low quality and quantity of discourse in computer-mediated discussion forums (Guzdial & Turns, 2000; Hewitt, 2005; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003), many empirical studies on knowledge building have shown that discourse in Knowledge Forum falls substantially short from what is envisaged by knowledge-building theory (e.g. Hakkarainen, 2003; van Aalst, 2006, 2009). Questions remain, in line with one of the major issues in the CSCL, how to characterize the process of collaborative learning (Meier, Spada, & Rummel, 2007; Spada, Meier, Rummel, & Hauser, 2005; van Aalst & Chan, 2007).

Relatively less is known about how to promote the interactions needed for the development of knowledge-building discourse in classrooms. Even though there is extensive research on assessing the quality of discourse in Knowledge Forum, it does not adequately examine the process of emergent and development of progressive idea advancements because of two main reasons. First, the grain size of discourse analyses does not take the interactional dynamics into account. To segment the Knowledge Forum database for content analysis, a series of discussion notes is often partitioned into individual notes (Lai & Law, 2006), question-and-answer exchanges (Lossman & So, 2010), and idea units (Hakkarainen, 2003). Using the fine grained unit of analysis

cannot show the role of collaboration in the quality of sustained inquiry, and it may lose the meaning of dialogues in the interactive process (Schrire, 2006; Stahl, 2002).

Second, coding schemes do not shed adequate light on the developmental process of knowledge-building discourse. Even though there is a movement using a larger grain size as an unit of analysis, such as inquiry threads (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007) and group discourse (van Aalst, 2009), the coding schemes mainly focus on rating the quality of individual ideas and neglect the role of community uptakes in progressive knowledge advancement. A good idea or note does not guarantee that it attracts public attention and has an impact on public knowledge, because it is possible that no one sustains the momentum to further develop the idea. For example, coding schemes, used in prior studies, focus on analyzing individual ideas according to their depth of understanding (Zhang, et al., 2007), explanation (Hakkarainen, 2003), inquiry (Chan, 1997), engagement (Lai & Law, 2006), nature of research questions (Hakkarainen, 2003), and lexical complexity (Lossman & So, 2010). Though there are some studies using excerpts from a series of notes to illustrate knowledge-building principles (van Aalst, 2009; Zhang, et al., 2007), they do not intend to systematically illustrate various discourse patterns emerged from the empirical data. Characterizing the process of knowledge advancement is important because it sheds light on the kinds of collaborations and interactions that classroom practices should aim to cultivate.

## Methodology

### Context of Research

This research is a part of a large research project on “Developing a teacher community for classroom innovation through knowledge building”, funded by the General Research Fund from Research Grants Council in Hong Kong. The participants in the project are around 70 teachers and their students. Those teachers have joined a teacher professional development program titled Knowledge Building Teacher Network (KBTN) which has been established in response to the recent educational reform in Hong Kong. In the KBTN, a knowledge-building community for supporting the teachers to develop expertise in implementing knowledge building is formed by an experienced researcher who acts as a co-investigator with the teachers to provide them with pedagogical advices, teaching strategies, and theoretical insights, in order to transform their conceptions of teaching and learning. The teachers meet regularly to build a public knowledge concerning good practice of knowledge-building pedagogies and assessment strategies.

### Participants

In this research, there are three teachers participants (hereafter called TA, TB, TC) from the KBTN. TA and TB are from a public primary (elementary) school, with students of low to average academic levels. TC is from a public secondary school, with students of average to high academic levels. The medium of instruction at both schools is Cantonese, and textbooks and teaching materials are in Chinese. All three teachers received teacher training in Hong Kong. At the outset of this research, TA had 8 years of teaching experience, and 2 years of experience in knowledge building; TB had 4 years of teaching experience, and 2 years of experience in knowledge building; TC had 10 years of teaching experience, and 3 years of experience in knowledge building. As for the student participants, in Study One, the student participants were from TA and TB’s Grade 4 Science classes and TC’s Grade 9 Chinese class in the academic year of 2009-2010. There were 108 students in total. In Study Two, the student participants are from TB’s Grade 4 Science class and TC’s Grade 9 Chinese class in the academic year of 2010-2011. There are 67 students in total.

## Research Design

### Study One

The goal of Study One is to develop a discourse scheme and gain an understanding of the characteristics of students’ discourses in Knowledge Forum. To this end, I developed the discourse scheme through an iterative process of top-down and bottom-up approaches, based on theoretical underpinnings and grounded in empirical data. The discourse scheme was then tested and further developed using three existing Knowledge Forum databases produced by the students of Grade 4 Science and Grade 9 Chinese classes in 2009-2010. These databases were chosen because many empirical studies on knowledge building examined Grade 4 to 6 Science students. And the biggest group in the KBTN is Chinese classes at junior high school.

### Study Two

The goal of Study Two is to exam discourse in Knowledge Forum and classroom practices, as well as the effect of knowledge building on student learning. The discourse scheme, developed in Study One, will be applied to analyze Knowledge Forum databases. The student participants are from Grade 4 Science and Grade 9 Chinese classes in 2010-2011. These two classes are chosen because they are taught by the same teachers in Study One.

Examining the same teachers' classes over a two-year period enables this research to track whether the teachers engage in more sophisticated classroom practices. Therefore, the focus on Study Two will be broadened from analyzing Knowledge Forum databases to investigating the social contexts in which the databases are created.

## **Instructional Design**

The instructional design in both Study One and Two incorporate various design principles of knowledge building and adapt a four-phase model that has been used in many prior empirical studies in Hong Kong classrooms (e.g. Lee, 2009; van Aalst & Chan, 2007). These four phases are cyclical and intertwined; therefore, teachers adapt them flexibly to cater for their contextual needs. The four phase model is reported in other studies (e.g. Lee, 2009; Lee, Chan, & van Aalst, 2006), and it is presented briefly in the follow.

### Developing a Collaborative Classroom Culture

Based on the principle of community knowledge, collective responsibility, the teachers cultivate a classroom culture to encourage peer interactions, contributions, and community knowledge advancements by conducting various group activities.

### Developing Knowledge Building Inquiry in Knowledge Forum

The students learn how to use the various functions of Knowledge Forum and continue their collaborative inquiry in Knowledge Forum. Drawn on the principle of epistemic agency, the teachers scaffold students how to formulate their own problems and questions to which students genuinely want to learn more.

### Deepening Collaborative and Emergent Inquiry

The principle of improvable ideas highlights the need of continuous creation and improvement of ideas; therefore, the teachers scaffold students to advance their inquiry by facilitating knowledge-building talks in which students work together to reflect on their emerging questions and understanding. As suggested by the principle of constructive use of authoritative sources, students are encouraged to read relevant information, summarize the key ideas, and connect the ideas with their inquiry in Knowledge Forum.

### Conducting Assessment of Knowledge Building

Toward the end of the inquiry unit, the students write reflective notes in Knowledge Forum to summarize the key ideas in Knowledge Forum, to demonstrate their knowledge growth, and to envisage further lines of inquiry.

## **Data Collection**

In Study One, data collection is limited to the Knowledge Forum database. Table 1 shows the data and analyses used to answer the first research question. Data of students' activities and social structures are obtained by the built-in tools (ATK and SNA) in Knowledge Forum through the server log records. Content analysis is conducted across different domains, in order to develop the discourse scheme.

Table 1: Data source of Study One: Exploratory case study.

RQ1. What are the characteristics of students' discourses in Knowledge Forum, with respect to the conceptual framework of knowledge sharing, construction, and creation?		
<i>Data source</i>	<i>Analysis</i>	<i>Purpose</i>
Knowledge Forum (KF)	Analytic Toolkit (ATK)	Assess overall participation: online activities
KF	Social Network Analysis (SNA)	Assess social structure: online communication patterns
KF	Discourse Analysis	Identify inquiry threads for major inquiry problems Characterize discourse features for capturing different discourse moves and patterns

In Study Two, the focus is on examining the classroom practice and Knowledge Forum in parallel. Multiple sources of data will be collected and used to answer the research questions.

Table 2: Data source of Study Two: Case study.

RQ2: How are discourses in Knowledge Forum created in the social contexts? And how does knowledge building affect student learning?		
<i>Data source</i>	<i>Methods</i>	<i>Purpose</i>
Knowledge Forum (KF)	Same as Study One	Apply the discourse scheme in Study Two Compare the various data between Study One and Two
Classroom	Classroom observations	Gain in-depth understanding of the design and implementation of classroom instructions

Teachers	Interviews	Understand the design and rationale of instructions
Students	Pre-post domain tests	Assess the students' domain knowledge
Same	Pre-post questionnaire surveys	Evaluate the students' conceptions of learning and knowledge
Same	Pre-post school exam score	Assess the students' academic achievement in traditional school assessments; Control student differences in academic ability
Same	Interviews	Probe into the students' conceptions of learning and knowledge building
Teachers	Interviews	Probe into the teachers' understanding and experiences

## Preliminary Results

The analyses of the data from two classes of Grade 4 Science students were finished. The results were reported on a conference paper titled "Principle-based design for collective growth: from knowledge-sharing to explanatory knowledge-building discourse" in CSCL2011. This preliminary results section focuses on reporting the development of discourse scheme and illustrating the scheme with empirical data.

The present study adapts the conceptual framework by van Aalst (2009) to distinguish the nature of discourses postulated as knowledge sharing, knowledge construction, and knowledge creation. The development of the coding scheme builds upon the idea of inquiry threads, defined "as a series of notes that address a shared principal problem and constitute a conceptual stream in a community knowledge space" (Zhang, et al., 2007, p. 125). It also builds upon the discourse pattern identified in Lee's (2009) dissertation demonstrating four categorizations of online discourse: (i) accumulation of information; (ii) information sharing; (iii) explanation-based of inquiry; and (iv) knowledge-building inquiry. The preliminary discourse scheme was developed based on empirical data from 298 classes, comprising different subject domains, such as Chinese, English, Social Studies, Sciences, and Visual Arts, and across different grade levels, from Grade 3 to Grade 13, in 4 academic years from 2006 to 2010. When I was a research assist in the KBTN, I read each class's database and selected the best cluster of notes from each of them. I studied the cluster one by one to decide which discourse nature could best represent them. Then the discourse analysis moved to a more objective measure as I recorded the discourse patterns and moves, so as to characterize the discourse features representing each nature of discourse. The preliminary result of the rating was presented in an international conference of Knowledge Building Summer Institute in 2010.

A five level coding scheme was further developed based on the data in Study One, and the scheme represents an ordinal scale indicating the extent to which an inquiry thread can be considered as knowledge-building discourse. The five levels are (i) knowledge sharing – fragmented, (ii) knowledge sharing, (iii) knowledge construction – low, (iv) knowledge construction –high, and (v) knowledge creation. Three major aspects in each level were emerged from different discourse patterns: inquiry approach, information use, and social metacognition. Table 3 shows an example of the scheme, (iv) knowledge construction – high (excerpt), and Table 4 characterizes the discourse patterns with empirical data.

Table 3: An example of discourse scheme: knowledge construction – high (excerpt).

Aspects	Patterns / Moves
Inquiry approach	Question-and-explanation exchanges: construct deep understanding progressively Explanations: use of hypotheses, conjectures, causal mechanisms, experimental results, equations, and analogies
Information use	Evaluates the veracity of sources and contents; Criticizes the incompleteness of information; Uses information to solve problems
Social metacognition	Clarification and Reflection; Questions others' explanations

Table 4: An example of using empirical to characterize the discourse scheme: knowledge construction (excerpt).

Knowledge Construction – Inquiry Approach		
Patterns	Student	Examples (Excerpts from inquiry threads)
<u>Question-and-explanation exchanges:</u> Good smell and nectar are explained as the mechanisms for fertilization.	YHC	☞ I need to understand ☞ Why do flowers smell good?
	FKH	☞ My theory ☞ Because the smell can attract insects for pollination.
	YMH	☞ My theory ☞ They are entomophilous flowers. Such flowers produce good smell and nectar to attract and reward insects for pollination.
	HSH	☞ I need to understand ☞ What are entomophilous flowers?
	YMH	☞ My theory ☞ Entomophilous flowers are the kind of plants that take advantage of insects for pollination. Pollination is for reproduction of next generation.

## Particular Issues in the Discussion

The particular issues in my dissertation and CSCL research I would like to explore include methods used in analyzing the content of asynchronous discourse and in capturing interactional and collaborative aspects of students' learning in both classrooms and computer-mediated discussion forum. I am also interested in receiving feedback and constructive criticisms on my dissertation

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## Supporting Getting Structural Elements for Constructive Interaction

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**Abstract:** The theme of my dissertation is to understand how to support lower division students to be able to learn from textbooks in collaborative learning. In 2004 to 2008, I was a member of the Chukyo Learning Science Group as teaching assistant, and made "Q-A Tool" which assists the students to grasp professional style texts about cognitive science through collaborative discussions. Q-A Tool is designed with question-answer format, like "What is the assertion of this essay?" to help students pick out "structural elements" such as theme, subjects, procedure, result, implication, and main assertion which distinguished in paper publication format. I found that students encouraged by the tool referred more elements than non-encouraged, in specific "implication" was significantly much. For future I would like to encourage building learner-centered knowledge upon their own intermediate implications in the series of students' understandings of texts and students' original thinking and activities.

### Goals of the Research

My research goal for the dissertation is to understand how to support college level, lower division students to be able to learn from college level textbooks, in collaborative learning situations. To achieve this goal, I have developed a support tool and assisted its classroom implementation for 5 years, from 2004 to 2008. Recently I finished some preliminary analysis of its effects by comparing the quality of the concept maps drawn by the students of 2003 when the tool was not used and of those of 2004 when the tool was used. I have found that in order to support lower division students, my tool was effective in terms of helping them develop skills to grasp the logical structure of technical materials. This kind of support is useful not by itself but when embedded in a well-designed, evidence-based curriculum which emphasizes constructive collaboration. Collaborative learning situations, even at college level, provide access to the students' real time learning processes through their utterances and externalized representations like concept maps, if we devise ways to analyze them properly.

For my dissertation, I plan to describe principles of designing classes to involve students into constructive interactions, mainly by scaffolding their grasping "structural elements" such as "theme", "evidence", "implication," and "assertion," as standardized for psychological papers (APA, 2001). The design consists of three steps. In its first step, I expand and study the effects of a tool I have developed to solicit the externalization of each student's own understandings of learning materials. In the larger study to enhance college level education at Chukyo University under my thesis advisor, concept map drawing has been used as a means of this externalization. The concept maps thus created are used to solicit explicit reflection for the students while being engaged in collaborative learning. So far I have developed and tested the effects of a "Question and Answer Tool" (Q-A Tool) (Tohyama & Miyake, in preparation) to support lower-division undergraduates to pick out structural elements from their assigned learning materials and set them up on their concept maps. The concept maps are drawn on a tool called "Reflective Collaboration Note" or ReCoNote (Miyake & Shirouzu, 2006) and used in classes run by the curriculum called "Dynamic Jigsaw" (Miyake & Shirouzu, 2006). I have researched the process and the effects of this environment as a Teaching Assistant (TA), using this as my research context.

### Background of the Project

In order to achieve the described goal, I have been using since my master's thesis to study a collaborative learning situation for undergraduates, in the classes where they are first introduced their expected majors technical materials. The class is designed as an elaborated version of the jigsaw for knowledge construction, the Dynamic Jigsaw. This method has been used to enhance and encourage externalizing what the students know, reflect, and construct into better understandings. This was also a tool for my research, because it allowed me to infer their cognitive aspects of their learning by analyzing what were externalized there.

### My Research Group

I was a member of Chukyo Learning Science Group in 5 years. The goal of the team is packaging "Super Curriculum" to teach cognitive science to undergraduates. The program designed for encouraging learner-centered knowledge construction (Bransford et al., 1999). One of its main design methods is the "jigsaw" (Aronson & Patnoe, 1997). The method is known to make student reach higher achievement above differences of their different knowledge backgrounds and cultures (Brown & Campione, 1994). We utilize it to promote the process of knowledge building for lower-division college students by "Dynamic Jigsaw".

### Theoretical Background

It is known that constructive interactions involve deep understandings that never occur in thinking oneself (Miyake, 1986). Such interactions require one’s thinking observable from the others (Shirouzu et al., 2002). But, students often feel difficulties to externalize their thinking.

Concept mapping is well known to make visible one’s knowledge formations (Novak & Gowin, 1984). It is also known in enhancing reflections like that: pair of college students using concept maps for their externalization tool got higher scores in writing summary reports than using tables or word-processors (Suthers & Hundhausen, 2002). So we provide students concept mapping tool for their knowledge externalization.

But a concept mapping activity for organizing technical publications is not easy for students. It is known that professional researchers can pick up structural elements and put them into spatially comparable arrangements but novices show difficulty only selecting structural elements (Miyake & Masukawa, 2001). It shows the only entering step of externalization is not easy for students. The reason seems that most Japanese college students never see academic writings until entering universities, so they don’t know how to read them and grasp its structures. We had to provide them the tool of helping detecting structural elements.

### My Research Context

My research context is the Dynamic Jigsaw (DJ henceforth) classes to teach first and second year students majoring in Cognitive Science. The DJ is a kind of knowledge building curriculum held since 2002. It is made up with students-centered collaborative interactions and some technological supporting tool. Students’ various activities reflected to verbal protocols and system logs were saved in detail. This program promotes constructing summaries for 2-years learning about cognitive science at the end of sophomores for 2 months.

In the program, there are 15 to 24 kinds of essays about cognitive science rewritten by the class teacher, such as language acquisition, child development, perception, problem solving, social psychology, and so on. They are written in the APA style (APA 2001), and most of assertions were built on some experimental evidences (see Figure 1). The essays have about 3,000 characters on two-sided A4 page. They belong to a “domain” which defines essays similarities. For example, Development, Problem Solving and Social Interactions are domains (see Figure 2). The domains and the essays are little different in each practice, but some of them are reused. This program requires students to construct their own implications from their own viewpoints through reading the essays and discussing associations collaboratively.

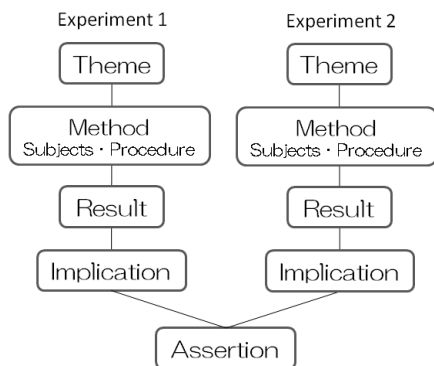


Figure 1. Structure of Essays.

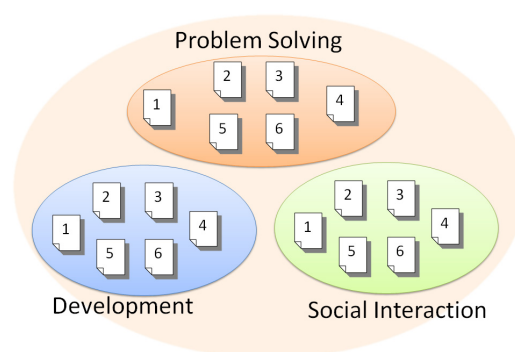


Figure 2. 18 Essays in 3 Domains.

To launch DJ, students are told to select one of essays for their own “assigned”. The students have to read it carefully because they have to explain it for colleagues who never read it. In this phase, students can talk with friends selected the same essay and use Q-A Tool and ReCoNote. Second, the student pair up with others who assigned different essay, and explain essays using their concept maps (see Figure 3). They can also ask questions about unexplained points, and suggest other viewpoints and associations between essays. At the next step the students explain both assigned and told essays with their implications like relationships between them. Repeating above procedure, they finally know all of the essays. Figure 4 shows a procedure of 18 essays.

For analyzing knowledge integration processes, TAs wrote down each pair of students’ name, their assigned essays, and progress of the explanations every class.

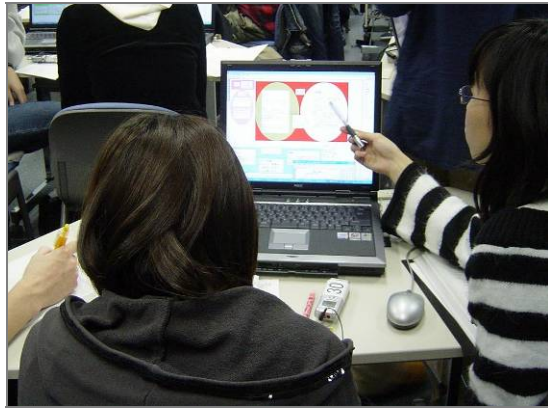


Figure 3. Explaining with a Concept Map.

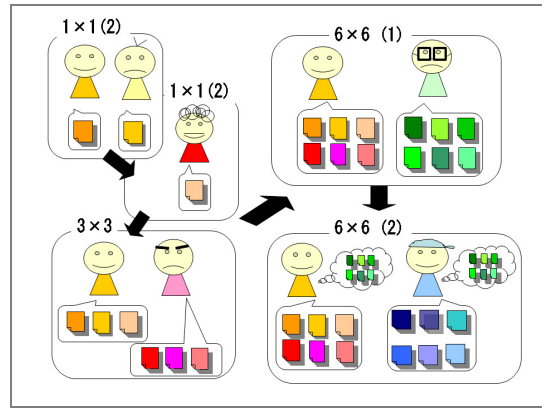


Figure 4. Dynamic Jigsaw with 18 Essays.

**(A) Q-A Tool: for Grasping Structural Elements**

Q-A Tool is designed with question-answer format. The tool asks the students about structural elements like “What is the assertion of this essay?”. The question set consists of 8 queries from 6 Structural elements; an assertion and evidences (theme, subjects, procedure, result and implication). The students require answering each question. The tool is built upon the CMS system called “SnipSnap” (a kind of wiki system). The students can use it in the term of preparing explanation of assigned essay, and anytime through the Internet. First, the tool requires login, then the students enter their own IDs. To answer the question, click the links and write an answer for each question (see Figure 5). The saved articles are automatically imported to writers’ own concept maps upon ReCoNote.

**(B) ReCoNote: the Concept Mapping Tool**

ReCoNote is the concept mapping tool consists of “Notes”, “Links” and “Sheets”. Notes are for saving fragmental information like keywords and brief sentences, similar to sticky notes. The Links show relationships between the Notes by line or arrow objects. And the Sheets perform as containers of both Notes and Links. The students can use above parts as many times as they like. Figure 6 shows a typical map made upon ReCoNote. The system allows us to access anytime from the Internet with authentication.

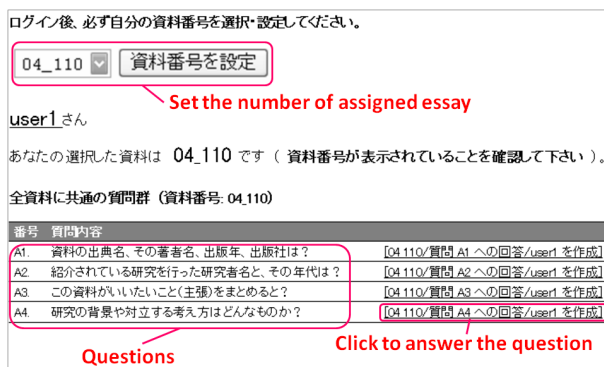


Figure 5. Screenshot of Q-A Tool.

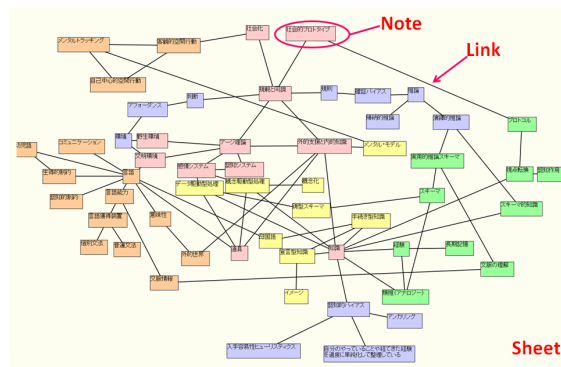


Figure 6. A Typical Concept Map Made by Students.

**(C) Recorded Protocols: about Collaborative Interactions**

All dialogues in DJ were recorded by IC-Recorders. While using Q-A tool and ReCoNote, the students talked about essays and their own thinking each other. So analysis of the protocols is necessary to get their understandings more correctly.

**Methodology**

Dynamic Jigsaw allows me to analyze and detect effectiveness of the QA tool, depending on the curriculum design.

For assessing this experimental practice, I can analyze 5 times DJs from a viewpoint of structural elements. Because the DJs constructed “design experiments” fashion (Sawyer, 2006), we can compare them like Figure 7 (the 2003 practice regard as a controlled). I analyzed (X) how structural elements picked up by Q-A Tool to concept maps with comparing the 2003 and the 2004. And for future work, (Y) we started to analyze how the students were influenced by class designs through comparing 2007 and 2008, and (Z) the effect of collaborative discussions using ReCoNote.

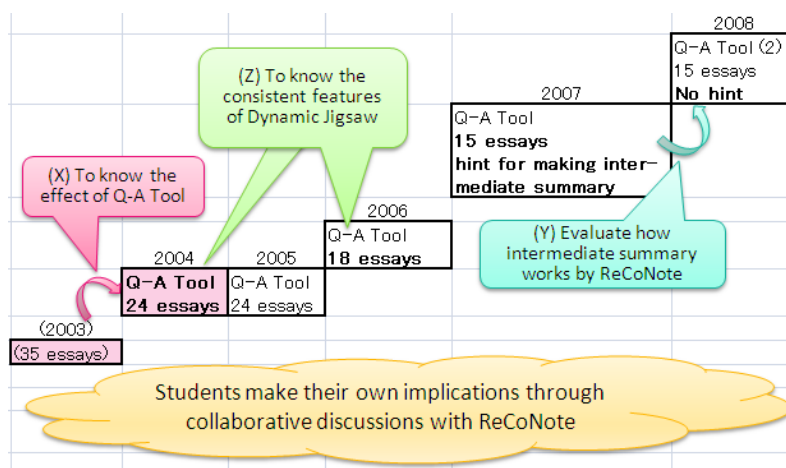


Figure 7. Designs of Repeated Dynamic Jigsaw.

We focused on the concept maps upon ReCoNote to assess the effect of Q-A Tool. We compared concept maps made by the student who assigned one of 9 essays which were used in both 2003 and 2004 practices. ReCoNote enabled us to know the effect of special arrangements and relation makings. We also checked the protocols of interactions, but detailed processes are now analyzing.

### Current Status, Preliminary Results or Result of Pilot Work

I have found that the Q-A tool was effective in terms of having the students grasp the structural component of their learning materials. By changing the design of the class to encourage using the tool, they could pick up the materials better in 2004.

I selected 41 concept maps upon ReCoNote about 9 essays made by 22 students in the 2003 and 19 students in the 2004. They were selected for comparing under equally conditions. Analyzing procedure consists of two measures: the first is the number of Notes and “ideaunits” on the maps, and the second is the number of ideaunits comes from each structural element. We broke down each structural element into ideaunits which consist of only one meaning.

The first assesses whether information keep separated for arranging them spatially. For example, Novak (1998) said the appropriate amount of information per Notes is 2-3 words. The second one shows how many information of the essays contained in the students’ maps.

The result of the first is that the number of Notes had increased as the ideaunits had increased (see Table 1). A Note in both 2003 and 2004 has average 1.73 ideaunits. It shows there are no problems in spatial arrangements.

Table 1: Average ideaunits in each Note.

	(1) Average # of Notes	(2) Average # of ideaunits on Maps	(1) / (2)
2003	9.45	5.48	1.73
2004	14.05	8.11	1.73

The second result in Figure 8 shows that how many ideaunits from each structural element of essays on an average each year. The 2004 shows high scores except “Theme”. “Implication” is significantly much ( $t=2.48, p<.03$ ). Figure 9 shows the average number of references to structural elements in each experiment in the essays which contain all 5 kinds of structural elements. In the 2004 structural elements were referred about 50% except “Theme”, and “Implication” was significantly much ( $t=2.10, p<.05$ ).

These results show Q-A Tool scaffolds the students picking up structural elements into the concept maps except “Theme”. It seems helping the students discussing collaboratively with showing contents of their assigned essays arranged by their own viewpoints. But picking “Theme” up was difficult to novices in the research domain. It may depend on amounts of domain knowledge. But if the student got it, they are ease to attend professional discussions comparing many kinds of researches. For it, we have to try making communities by both professionals and novices.

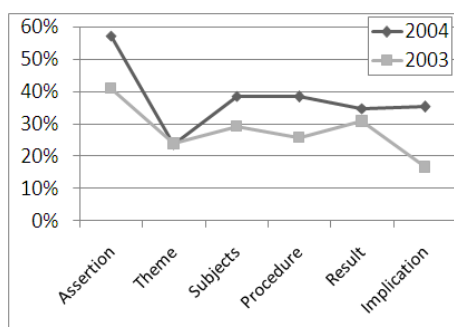


Figure 8. Average Ideauunits on Structural Elements.

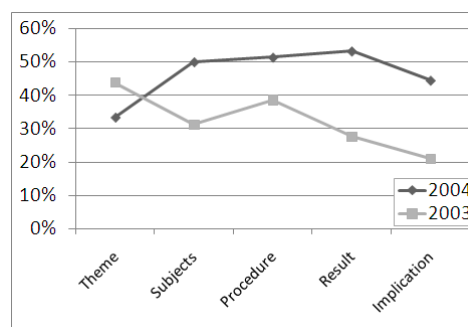


Figure 9. Average References to Structural Elements.

## Particular Issues/Problems in My Dissertation & CSSL Research

I would like to expand my research to find out how to better design lower division classes not only in cognitive science but in other areas. This would include taking advantages of the kind of tools, concept mapping, and design of collaboration, by analyzing and understanding their strengths, particularly when blended. In order to approach to this goal, I plan to analyze collaboration utterances and concept maps in order to find out what triggers changes of their material understandings, so that they could progress.

To consider such blended approach by design of collaboration, I am now analyzing the effect of “intermediate summaries” to link far domains of knowledge in collaborative situations. The result is that the students in 2007 externalized the domains’ summary than in 2008 ( $t=3.11, p<.01$ ) because they were given hints for summarizing (see (Y) in Figure 7). In 2007, more students referred 5 domains on concept maps than in 2008, and made links between domains than in 2008. But the term papers were seldom written about relationships among the domains both 2007 and 2008. The result is that intermediate summaries worked for link among far contents, and knowledge externalization with concept maps enables us to observe students’ internal knowledge connections. I have to find the way how to construct summaries from students’ points of view, not depends on given hints. I hope to college students do self-directed learning with colleagues about professional learning materials.

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## Activity-based Tools to Support Orchestration of Blended CSCL Scenarios

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**Abstract:** The technological and pedagogical complexity of teaching practice is increasing, as new ICT tools and pedagogical approaches are added to the teachers' repertoires. Teachers are thus required to play more and more the role of “orchestrators” of the learning experiences of students. This document presents a PhD thesis centered on the design, development and evaluation of tools (both conceptual and technological) to support teacher orchestration in the context of blended CSCL in heterogeneous learning environments (involving multiple hardware and software tools). Socio-cultural activity theory is proposed as the main theoretical underpinning of this work. The document presents briefly the context of the research problem, the goals of the thesis and the methodologies that will be used. It also summarizes the findings obtained so far and highlights a number of problems and challenges, mostly methodological, that the author would like to explore during the Doctoral Consortium workshop.

### Background of the Problem

The increasing use of ICT tools in the realm of education at all levels has opened up a host of new possibilities for learning experiences and educational approaches not possible before, such as distance/online learning, the technologically-enhanced classroom or the combination of both, that is often referred to as blended learning. Along with these new forms of teaching and learning, teaching practice is slowly steering away from traditional initiation-response-evaluation sequences towards multiple pedagogical approaches that are being used nowadays in the classrooms, such as project-based learning, collaborative learning, inquiry-based learning, etc. Blended, computer-supported collaborative learning (CSCL) scenarios are at the crossroads of these two trends, and are becoming increasingly common, especially due to educational reforms that foster that kind of practice (Declaration, 1999).

To the complex mosaic of pedagogical practices depicted above, an additional layer of technological complexity is added, as classrooms are progressively transformed into complex technological ecosystems of tools (Luckin, 2008). Nowadays it is not uncommon to find digital whiteboards, desktop computers, laptops and a myriad of software tools co-existing with pen, paper, books and chalk. Among the ICT learning tools whose usage is on the rise, we can especially mention virtual learning environments (VLEs), personal learning environments (PLEs), but also a host of “web 2.0” tools (e.g. wikis, blogs, collaborative writing software, social networking software) that are used for learning (Conole & Alevizou, 2010). How is a teacher to make sense of the limitless array of options (considering both pedagogy and technology) at her disposal?

In the field of computer-supported collaborative learning (CSCL), the metaphor of teachers “orchestrating learning” has been coined to acknowledge this complexity. (P. Dillenbourg, Järvelä, & Fischer, 2009) define orchestration as “the process of productively coordinating supportive interventions across multiple learning activities occurring at multiple social levels”. In the case of blended learning scenarios, this coordination also involves the use of multiple tools (ICT or not) across the different contexts where learning can take place (e.g. the classroom, at home, a field trip, etc).

The orchestration of blended CSCL activities involves a number of different actions or phases, in what we could call the activity lifecycle (Gómez-Sánchez et al., 2009): the preparation of the learning activities (design); the deployment/contextualization of the designed activities to address the concrete tool instances, participants and groups that will participate in their execution (instantiation); the execution of the activities themselves (enactment); and, eventually, the revision and refinement of those activities (evaluation). These phases, however, do not necessarily happen in a strictly sequential fashion, and the very notion of orchestration seems to imply some kind of “flexible lifecycle” (Jullien, Martel, Vignollet, & Wentland, 2009), as teachers are expected to assess and adapt their interventions and activities to the occurrences and evolution of the classroom (P. Dillenbourg & Jermann, 2010). A teacher trying to orchestrate blended learning activities in this kind of heterogeneous environment is faced with several problems:

- Currently there is a disconnection between the design of activities (which can be expressed using a variety of learning design tools and languages) and their execution in these heterogeneous environments. The deployment of the designed activities in the learning environment commonly involves manual, time-consuming and error-prone steps. Even if there are a number of recent proposals supporting the integration of the execution of external tools in learning environments (Alario-Hoyos & Wilson, 2010; de-la-Fuente-Valentín, Pardo, & Kloos, 2011; Perez-Rodriguez, Caeiro-Rodriguez,

Anido-Rifon, & Llamas-Nistal, 2010), none of them supports a (non-expert) teacher in going from a learning design to its deployment and enactment, without forcing the user into a concrete implementation of learning design tool, learning environment or external tools.

- There are also cognitive problems associated with this orchestration of heterogeneous web learning environments. Having the learning activities spread over a number of heterogeneous tools can make the activities, their structure and purpose unclear. Moreover, if the teacher is to adapt the deployed learning design taking unexpected occurrences into account, a way must be provided to help teachers in making those changes in a straightforward way. Thus, support for the orchestrated execution of the activities is needed.
- Even if the learning design has been successfully deployed across this heterogeneous set of learning environments and tools, and there is certain support for their orchestrated execution, there is evidence that the tools themselves or the learning design alone do not guarantee the success of a learning scenario. Rather, *how* those tools are used and other contextual factors such as the classroom rules and atmosphere also have a great influence in such success (Vass & Littleton, 2010).

This document describes a PhD proposal that intends to *provide tools for the support of the orchestration of blended CSCL activities involving heterogeneous learning environments*. Here, the word “tools” is used in the widest sense, involving both conceptual as well as technological tools that may help practitioners in performing this orchestration. This research effort is related (as long as the integration of external tools and learning environments is concerned) to one of the aforementioned initiatives for the integration of virtual learning environments and external tools: the GLUE! architecture (Alario-Hoyos & Wilson, 2010). However, the deployment and execution support may be independent of GLUE! in case that no external tools are used. The document describes, in the next sections, the goals of this research effort and the methodologies that will be used to fulfill those goals. Afterwards, preliminary evidences are presented, and the document closes with a summary of the open questions and problems that the author would like to explore during the Doctoral Consortium workshop.

## Goals of the Research

As it has been hinted in the previous section, this PhD proposal aims to develop tools to support the orchestration of heterogeneous learning environments, especially in blended CSCL scenarios. In order to do this, we have chosen Activity Theory (AT) (Engeström, 1987) as our main theoretical and analytical lens, which we will use to generate hypotheses, artifacts and conceptual frameworks. This decision is based, not only on the wide predicament that this theory has on CSCL research (Gifford & Enyedy, 1999; Jonassen & Rohrer-Murphy, 1999), but also on its ability to model complex practices (orchestrating learning in a heterogeneous environment is certainly complex) and the influence of mediating tools in those practices. Thus, we could formulate the main goal of this thesis as:

*“To design, implement and evaluate activity-based tools to support the orchestration of blended CSCL activities involving heterogeneous learning environments, and in particular the deployment and execution of learning designs across those environments.”*

There are several terms in that goal definition which deserve further explanation. By “activity-based” we mean that the conceptual framework and the proposals of the thesis will be done bearing in mind the main tenets of Activity Theory. As AT itself proposes, the mediating tools in any human activity include both conceptual and technological tools, and in this sense the word “tools” is used above. By “learning environments” we mean virtual learning environments (VLEs) or any other ICT infrastructure which can centralize the learning experience, such as personal learning environments (PLEs), or even wikis and blogs. Finally, we must point out that this research effort is mainly directed to supporting non-ICT-expert teachers, who most often perform this orchestration. However, educational contexts where students participate on the orchestration (e.g. by choosing the activities to be done or the tools to be used) may lead us to include the student perspective as well.

To achieve this goal, we could define a number of *partial objectives* of the thesis, which largely correspond to solutions to the orchestration challenges presented in the previous section, by looking at those challenges from an activity-theoretical perspective:

1. The definition of the concept of orchestration of learning, particularizing it to the context of blended CSCL activities in heterogeneous learning environments, analyzing the challenges for orchestration that these settings pose, and *proposing a conceptual framework that helps* (us and other researchers) *in devising solutions to support such orchestration*.
2. To bridge the current gap between learning designs and its deployment across heterogeneous learning environments that include multiple tools. Since activities are a crucial concept in most learning design

languages and learning environments, we propose *to design, develop and evaluate a technological infrastructure for the deployment of learning designs in heterogeneous web learning environments*, based on the concept of activity, without tying users to a particular VLE or learning design tool/language.

3. As a way to overcome the fragmentation that can derive from the usage of heterogeneous and decentralized sets of tools across different times and contexts, the idea of activity-centred computing was proposed in the field of CSCW (Christensen & Bardram, 2002), influenced by AT. We propose *to design, develop and evaluate an activity-based system to support the execution of blended CSCL activities in heterogeneous learning environments*, to increase the usability of the orchestration process, enabling the manipulation of activities and other important activity elements (like participants or tools).
4. In order for orchestration to be effective, not only the designed activities have to be devised towards certain pedagogical goals, and that design be deployed and executed in the ICT infrastructure. The actions and operations taken during the enactment of the activities have to be aligned with those goals, so that they really are “supportive interventions” (P. Dillenbourg et al., 2009; L. P. Prieto et al., 2011). Albeit their nature is largely context-dependent, *best practices, rules, routines and patterns can be used as mediating tools* by teachers (especially non-expert ones) to help them in orchestrating activities. Thus, we aim *to propose and evaluate a set of contextualized best practices, patterns, routines and rules for the orchestration of blended learning activities in heterogeneous learning environments involving external tools*. Also, *recommendations for the elicitation, proposal and evaluation of this kind of elements* in other contexts should be provided.

## Methodology

The problem of orchestration in heterogeneous web learning environments is framed in the multidisciplinary problem domain of CSCL. We have selected a hybrid methodology such as the *engineering method* (Adrion, 1993) as the general methodological framework of the thesis, following four general phases: informational, propositional, analytical and evaluation. Within this framework, and given the constraints for research in orchestration (P. Dillenbourg, 2009), we have to consider carefully the social context, combining theory and praxis to focus on real practitioners’ needs. Thus, for each of the four partial objectives presented in the previous section, the four phases of information, proposition, analysis and evaluation are being followed iteratively, each cycle informing subsequent cycles along the same objective, but also providing valuable information to the other lines of work (especially, to the conceptual framework which will serve as the main unifying structure of the thesis’s solutions). Given the focus of CSCL research in the social context and the importance of those factors in Activity Theory, it follows that evaluation experiences should be situated in authentic educational settings, and that our evaluations should take into account as many of the myriad of contextual factors as possible. This fact points in the direction of naturalistic approaches to the evaluation of our proposals. More concretely, (Jorrín-Abellán & Stake, 2009) propose a “responsive evaluation” framework (CSCL-EREM) to be used by CSCL practitioners, which use case studies as its main evaluation technique. Albeit this kind of studies have the disadvantage of not being designed to provide generalizable findings, we will strive to accumulate evidence from different educational contexts, so as to increase the credibility of the applicability of the thesis’s artifacts, at least, to a number of similar educational contexts. More concretely, the thesis is involving field work in a primary school in Spain, as well as several undergraduate and postgraduate courses at the University of Valladolid.

Another important methodological issue that we face is that of measuring the success of a learning experience from the point of view of orchestration. In order to do that, a number of *success criteria* are proposed:

- The *workload* of teachers using the proposed tools when instantiating, deploying and enacting blended learning activities *is reduced* (e.g. faster setup of lessons using multiple ICT tools).
- *User satisfaction* when deploying and enacting the activities *is increased* (e.g. the deployed infrastructure matches the design that the teacher had defined; desired changes are successfully made to the ICT tools in the face of unexpected occurrences).
- *User effectiveness* when deploying and enacting activities using the proposed tools *is increased* (e.g. the learning experience “works” in the classroom).
- Application of the aforementioned metrics to *students*, in the contexts where such student-led orchestration is present.

## Preliminary Results and Current Status

There have been a number of preliminary results on the different objectives of the thesis presented above:

1. Regarding the definition and conceptual framework on orchestration, a preliminary literature review and a first framework proposal has been made, and is available in (L. P. Prieto, 2010). A second,



deeper joint work to provide a more complete review and comparison with real-world practice, is currently in the works (L. P. Prieto, Abdulwahed, Balid, Holenko, & Gutiérrez, 2011). Also, a joint paper to be presented at this very same conference analyzes teaching practice in a heterogeneous environment from the point of view of Activity Theory, highlighting the importance of patterns at different activity levels as mediating tools for orchestration in the classroom (L. P. Prieto et al., 2011).

2. The technological infrastructure for the deployment of learning designs in heterogeneous learning environments is in its propositional phase: a service-based architecture for such deployment, composed by an activity service and adaptors for each learning design tool/language (e.g. IMS-LD) and target learning environment (e.g. Moodle) has been proposed. Also, a set of concepts that serve as *lingua franca* for the translation of learning designs to ICT infrastructure has been proposed. The implementation work on this deployment infrastructure has just started.
3. The technological support for the flexible execution of the deployed learning designs is also in the propositional phase, similarly composed by an activity service and adaptors. We are currently defining the requisites that such a system should fulfill.
4. Regarding the proposal of best practices for blended learning orchestration in heterogeneous environments, its informational phase began with a case study in a primary school in Spain, which analyzed how teachers designed and enacted (i.e. orchestrated) their activities with technology (L. P. Prieto, 2009). From this study emerged the importance of teaching routines both for the analysis of activity designs (L. P. Prieto et al., 2010) and of activity enactments (L. P. Prieto, Villagrà-Sobrino, Jorrín-Abellán, Martínez-Monés, & Dimitriadis, 2011). This line of work also highlights the usefulness of these routines and other small-scale patterns in professional development interventions for teacher innovation, which is hinted at in (L. P. Prieto et al., 2011), and further developed in (L. P. Prieto et al., 2011).

## Problems to Explore at the DC Workshop

As we can see from the previous section, up to now the conceptual framework and best practices for orchestration have been developed further than the other thesis strands, and we are currently focusing on the design, implementation and evaluation of a technological infrastructure that embodies such concepts. While this implementation effort is in its early stages, we are considering which is the best way of evaluating such technological scaffolding. Furthermore, for the orchestration conceptual framework (one of the main contributions of the thesis), the question of how to evaluate/validate its usefulness is not completely clear yet.

Along the same lines, the methodological structure of the whole thesis is being considered, since it contains very different elements which may or may not be used together (although the idea of combining – or rather, orchestrating – them for more effective results comes to mind intuitively). Although the CSCL-EREM framework has been proposed as a starting point for the evaluation of the thesis contributions, different evaluation techniques are being considered at this point, considering both their validity and the amount of effort needed to put them into practice (given our limitations in time and effort): design-based research, mixed methods, multi-case studies, etc. The author hopes that this kind of methodological concerns (both for this concrete thesis and in general for CSCL research) will be addressed during the Doctoral Consortium workshop.

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# Social Network Analysis of Collaborative Knowledge Creation in Wikipedia

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**Abstract:** This paper presents my dissertation project on online socio-cognitive networks. My focus of interest is on collaborative knowledge creation in Wikipedia, the Web 2.0 application with enormous impact in the spheres of human learning and knowledge. The online encyclopedia presents a unique field for studying processes of large-scale mass collaboration. This development is of great interest to psychology among many other disciplines. Accordingly, my dissertation is directed at studying the interaction of social and cognitive processes intersecting the levels of individuals, groups and communities. In order to unveil the interaction mechanisms I am taking up a network level perspective utilizing social network analysis metrics and methodology for psychological research questions about knowledge creation.

## Research Goals

Through my dissertation I want to advance the academic knowledge about online socio-cognitive networks. My focus of interest is on collaborative knowledge creation in Wikipedia as an example of Web 2.0 application with enormous impact in the spheres of human learning and knowledge. The online encyclopedia presents a unique field for studying processes of large-scale mass collaboration. Compared to the typically small-scale studies in CSCL it is important to build up understanding of such new social software phenomena where thousands of people engage in conscious contribution to a project.

It has to be recognized that Wikipedia is not a mere composite of single pieces of information. It is not a product of independent individual contributions either. It is rather a vast system of collaborative and coordinated activities of a myriad of individuals. Based on wiki technology Wikipedia is categorized as social software, but the growth of its size and popularity adds up to a new level of dimensionality – it becomes society software. This development is of great interest to psychology among many other disciplines. Accordingly, my dissertation is directed at studying the interaction of social and cognitive processes intersecting the levels of individuals, groups and communities.

In order to unveil the interaction mechanisms I am taking up a network level perspective. My focal subject of study is the emergence of knowledge artifacts created by a network of individuals. I investigate different groups of Wikipedia authors according to their level and style of contribution as well as different stages of development of the authors in general. The individual position of authors in the global network structure is taken into account. Wikipedia log data at micro- and macro-level is statistically analyzed considering also the temporal dimension.

In my first study I compared contributors to a single or both of two related knowledge domains. I used centrality metrics from social network analysis (SNA) in order to quantify the impact of both types of contributors in the network of articles. I focus on the process of integration of knowledge domains in attempt to answer the following questions: What characterizes the contributors driving this process? What are the mechanisms of its temporal dynamics? Statistical evaluation of the temporal dimension will be performed in subsequent studies.

An implicit goal of my project is to provide an example for utilizing social network analysis metrics and methodology for psychological research questions that measure up to the complexity of network-level perspective.

## Background

My project is grounded in the CSCL research tradition but deals with the topic from a psychological point of view. While CSCL is a young research field, it is also marked by heterogeneity of views on the main phenomenon of interest, attracting researchers with diverse scientific backgrounds – anthropology, psychology, computer science, and others. It builds on the insights how cooperative learning in groups can result in more effective outcomes for individuals (cf. Johnson & Johnson 1989; Slavin 1991, 1995). In contrast to the perspective of the individual, CSCL stresses the processes within the social context of learning like participation in community and negotiation of meanings.

However, there are also some theoretical perspectives contradicting the potential of collaborative learning and knowledge building. Knowledge sharing can be obstructed as in case of information exchange dilemmas (cf. Cress, Barquero, Schwan, & Hesse, 2007). Strategic incentives can be missing or misaligned, so that it is not beneficial for an individual to contribute. Also, coordination of group activities costs much time

and effort, so individuals can prefer to learn independently. Following the theory of public goods it seems even more implausible that collaboration can happen on the Web because of users' anonymity and the lack of universal authority.

In sum there are diverse models of collaborative knowledge processes and they give a different understanding of how individual knowledge is integrated. A major question is whether to conceive learning and knowledge as property of the individual. An answer can be found in the relatively old idea that individual learning and collaborative knowledge building are two coupled processes (cf. Scardamalia & Bereiter, 1994). The specific conditions for successful learning and knowledge building require a detailed analysis on different levels. Ultimately, psychological research cannot be confined to the level of individuals even if the solely object of study is individual learning through social software. A major challenge to psychological and educational theory is to integrate concepts of individual and collective knowledge into a coherent exposition. Research has to account for interaction of individuals, for group level processes, for community level organization and for the interplay between all levels.

CSCL implies utilization of computers in learning practices, so the role of technology is also important aspect of the phenomenon and needs to be studied. Moreover, it could reveal the missing link between individual and collective knowledge. People can for instance use social software to interact with each other and form communities appropriating the technological affordances. Computers can surely initiate and support the collaborative learning process. Lipponen et al. (2004) describe them as transformative artifacts that mediate learning in social contexts and support the coupling among individuals' knowledge.

The function of mediating artifact can be fulfilled not only by the connecting technological infrastructure but also by any knowledge object or element of communication. Paavola, Lipponen and Hakkarainen (2002, 2004) have introduced the metaphor of *knowledge creation* referring to the long-term collaborative production of shared dynamic artifacts, like physical objects or even abstract ideas. Theoretical CSCL models focusing on this aspect explicitly deal with the interplay between individual and collective knowledge. They may also be applied to global knowledge processes at the level of society like scientific progress. Adapted to the context of wiki communities the co-evolution model of Cress & Kimmerle (2008) is another example for the perspective on artifact mediation in the process of collaborative knowledge creation.

The co-evolution model describes a detailed influence mechanism, i.e. co-evolution between the mediating artifact system of a wiki and the cognitive systems of its users. Naturally, the adoption of a systemic perspective allows for an integrated view of all relevant levels and takes an appropriate account of the complexity of interacting processes. Incongruities between the individual knowledge and the information in the wiki can create a cognitive conflict that eventually leads to co-evolution. Interaction between the systems is most likely to occur when the incongruities are at a medium level. Depending on the personal valence of a given topic and on the amount of new or contradicting information, an individual not only advances his or her knowledge when reading, but he or she can also contribute to the development of the shared knowledge. Externalized knowledge becomes a mediating artifact that allows further co-evolution cycles. The model conceives individual learning and knowledge building as emergent systemic phenomena. This means they are global products of many locally interacting system components, so that knowledge is produced through the integration of many pieces of information by many thinking individuals.

On a large scale Wikipedia is the most remarkable example of collaborative knowledge processes based on the use of wiki technology. Forte and Bruckman (2006) investigated them and concluded that they are comparable to the knowledge building model of Scardamalia and Bereiter (2006). A wiki represents a complex artifact that contains more than one article. The articles are connected in different ways, e.g. through direct links and the categorization system. Moreover, a wiki offers an explicit account of the shared knowledge. The artifact is not only the object of creation, but also the tool that structures the creation process. Work is executed in an asynchronous way, and the project is open-ended. As in any open-access wiki, Wikipedia authors who collaborate on one article do not and cannot know each other personally. So, although there are lively discussions on the content of many articles and various codified rules coordinate the process (cf. Niederer & van Dijck, 2010), a significant amount of the interaction between the contributors is mediated through the developing artifact itself. The community expands its knowledge base through discourse and negotiation. Disagreements and conflicts are solved in communicating through the wiki contents.

Knowledge often manifests itself as a collective phenomenon. Large-scale knowledge practices present new questions for the CSCL research regarding emergent social phenomena and the dynamics behind them (Stahl et al. 2006). Together with increasing connectivity in modern society the rapid changes of knowledge media and the Internet present a challenge to understanding collaborative knowledge building and learning. While multiple CSCL models relate to interactions of small groups in a problem-solving setting, knowledge creation models 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 development and spreading use of Web 2.0 technologies. A central characteristic of this development is that relevant information comes not primarily from qualified experts but also from peers. Openly accessible

knowledge is produced by learners themselves, often in a collaborative effort and in informal setting. This parallels constructivist perspectives that stress the importance of active participation for effective learning as opposed to passive reception (cf. Cohen, 1994). A consequence for the CSCL research is that the focus increasingly shifts away from the concept of learning to that of knowledge creation.

In addition to the micro perspective of learning individuals and the meso perspective of group discourse, mass collaboration introduces the macro perspective of knowledge creating communities as networks (Lipponen 2002, Ryberg and Larsen 2008). This global level has only rarely been the focus of CSCL research and goes beyond the co-evolution and other knowledge creation models. Wellman (1997) described networks as social structures with certain patterns, which consist of a set of individuals and their relationships. Communities on the Internet often constitute larger networks where not all of the participants know each other, and communication is primarily computer-mediated. So, connections between the network parties are more loose and fluid. Basis of such communities are single common aspects like shared interests or pursuing mutual project goals. Given the large scale, participants are very diverse and possess heterogeneous knowledge. Wikipedia for instance promotes the integration of different and even contradictory aspects or entire theories into one network of knowledge. It is therefore interesting to investigate how common understanding of broader issues or entire knowledge domains develops out of different opinions of diverse sub-groups. The macro perspective takes then into account the structure of the community network, the relative positions of the participants and their influence on the knowledge base, in order to explain *emergent knowledge* on global level.

The concept emergent knowledge denotes knowledge that arises within a community network and reaches qualitatively higher level than the mere sum of what all individuals in the network know. Emergent knowledge arises only through collaboration in the process of knowledge creation. Although it is based on the activities of individuals, it is not reducible to their antecedent knowledge. Both the structure of the shared knowledge base like the wiki content, as well as the impact of various authors on this structure must be taken into account in order to explain emergent knowledge. Considering the interaction of many components in a knowledge creating system, network science offers tools for the analysis of its complexity. This approach corresponds with the need for methodical multiplicity, in order to capture the mechanisms of knowledge creation on multiple levels (cf. Cress, 2008).

## SNA Methodology

Social network analysis (SNA) is the central methodology in my research project. Although originated under the name of sociometry by a psychologist, Jacob L. Moreno (1934), it was mainly used and advanced by sociologists. It consists of a variety of methodical concepts and instruments to identify, describe, analyze and visualize social relations, positions, clusters and global network properties. Methods for analyzing network changes over time are also used and further developed. Although mostly used for generating descriptive statistics, there are some techniques for statistical inference based on SNA. Again this is an area of current development. The methodology is perfectly suitable for exploratory as well as confirmatory approaches, and for generating and testing hypotheses. For a detailed exposition of the SNA methodology, see Wassermann & Faust (1994).

SNA is increasingly adopted in studies of computer-mediated interaction on forums and wikis. As such interactions and relations are mediated through a shared digital environment, large amounts of detailed log data are available for the whole period of existence of a community. The challenge of using SNA in a CSCL study lies in its adaption to the psychological perspective, as many of the methodical concepts were developed in correspondence with sociological theories. Nonetheless, it is a methodology that very well suits the macro perspective on knowledge creating networks and provides a structuralist approach to the relevant processes.

Kimmerle et al. (2010) presented an interesting study employing SNA on a network of Wikipedia articles that are connected to the topic of schizophrenia. Not the content of the articles but their relations constituted the focus of analysis. The network was defined as a set of articles connected by hyperlinks to each other. Using an algorithm clusters of densely connected articles were identified, which corresponded to the different explanation models of schizophrenia. Over the years of Wikipedia's existence the automatically detected clustering evolved in parallel to the development of scientific understanding of the matter. Two of the initially separate clusters, which represented a biological and a social approach, merged in the later years into a common cluster representing a newer explanation model. The integration of contents was ascribed to a certain group of authors of articles that were writing for both initial perspectives. These authors were called *boundary spanners*.

Boundary spanners (Tushman und Scanlan 1981) have knowledge in different domains and participate in more than one subgroup. Due to their bridging network position they drive knowledge exchange between various perspectives. As the results of Kimmerle et al. (2010) showed they play a special role in the process of knowledge creation and may hold the key to emergent knowledge (cf. Hoe 2006).

In sum, the macro perspective on knowledge creating networks offers an exciting and largely unexplored approach to the problem field of CSCL. Correspondingly, SNA is the appropriate methodological

approach to this perspective. Applied to data from Wikipedia, SNA can help to identify central individuals in single knowledge domains as well as individuals bridging the differences between knowledge domains. In my dissertation I use common measures like closeness and betweenness centrality (Freeman 1979) in order to characterize the position of single articles in the network of predefined knowledge domains. I focus on phenomenon of knowledge connection and integration. Based on the article centralities I develop hypotheses about the contribution behavior of Wikipedia authors.

## Current Status

My first study was based on the findings of Kimmerle et al. (2010) on the role boundary spanners take.

I included around 4700 articles from the two adjacent knowledge domains pharmacology and physiology and investigated their interlinkage. The main questions were, on the one hand, how integrative knowledge arises and, on the other hand, what are the characteristics of the people promoting it. Under the assumption that integrative knowledge is a more complex form of knowledge, I hypothesized that building it requires an expertise in both domains. So, authors who simultaneously write in two knowledge domains in Wikipedia were expected to contribute relatively more to articles that interconnect both domains. That would be articles that are relatively well connected and have short hyperlink paths to topics from both domains

Both knowledge domains together form a network that consists of articles and hyperlinks connecting them. I calculated SNA measures of betweenness and closeness centrality for each of the relevant articles identifying the interconnection value of its position in the network. In the end I differentiated two single networks, one for each of both knowledge domains, and a third network combining all articles from both domains.

Articles centralities were then aggregated for each author calculating the average on the specific articles each author has contributed to. Based on contribution to only one or to both knowledge domains authors were divided into two groups – as single-domain contributors or as boundary spanners. Both groups of authors were then statistically compared in their impact on the integration of the knowledge domains.

My main hypothesis was that there is a distinct role of contributors that function as boundary spanners. They would not only make separate contributions to both knowledge domains but would be also responsible for integrating the knowledge from both domains. They were specifically expected to create more articles that interconnect both domains but are not central to the single domain networks. The aggregated betweenness and closeness measures of these authors were expected to be significantly higher than the measures of single domain contributors in the combined network of articles but lower in the single domain networks.

The results of my first study delivered a partial confirmation of my hypothesis and introduced interesting possibilities for further investigations. I could show that the integration of knowledge domains is performed by very active and experienced Wikipedia authors. They write the intersecting articles and take up central, interconnecting positions between knowledge domains. Interestingly, this role corresponds with a dominating position within the single domains, so boundary spanners did not only connect different domains, but also contributed to the most central articles of the single domains.

Single-domain contributors had written content of some potential value, but have not developed further, so their part is characterized by a low to middle level of contribution, and their articles are not so viable for the network. This peculiarity appears to be a general feature of wikis: a small number of authors do most of the work, including the organization of content. It also seems to be connected to the idea of legitimate peripheral participation in the research on communities of practice (Lave & Wenger, 1991).

For the present study I focused on testing the formulated hypotheses and did not analyze much personal information but recognized some interesting discrepancies between the predefined groups of authors. One of the future directions of work will be to study these differences in detail, in order to identify the relevant groups of authors more precisely. A more exciting question to investigate would be the pattern of temporal development of knowledge domain connection and integration, again through the perspective of a network. For this purpose the handling of temporal data and testing of complex models will be the major challenge.

My first study has been presented at the WikiSym 2010 (Halatchliyski, Moskaliuk, Kimmerle, & Cress, 2010) and at SNA conferences receiving much attention. It has been submitted for a book on network analysis in the social sciences. Until the end of my dissertation I will replicate that study on larger knowledge domains including some additional perspectives in the calculations. The results will present a basis for a journal paper that will have been submitted by the time of the CSCL 2011 conference. A new larger study will then be the current concern.

## Discussion

Apart from meeting other researchers with interest in SNA and CSCL, from your workshop I expect to obtain invaluable feedback on the ideas and argumentation of my project. I would like to discuss different perspectives on the implications of the results from my first study. What would be the most important question to explore

next? I will be then especially interested in different ways of addressing temporal dynamics in data. What statistics are appropriate for combining attribute and relational data?

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## Collaborative Knowledge Exchange using Patterns

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**Abstract:** Often the exchange of knowledge-in-use between practitioners with different degrees of expertise is laborious, as there is no way of directly observing it, and knowledge-in-use often only exists in implicit form. So it is difficult to externalize and to share it with others. This project of a doctoral dissertation focuses on the question of how the exchange of knowledge-in-use can be supported in such a way that it is adaptive to the needs of all practitioners. This dissertation investigates the influence which patterns (i.e. given structures to fill in) may have on the externalization, internalization and evolution of knowledge-in-use. Two studies on knowledge externalization have already been carried out and are presented in this paper. First results indicate that the use of patterns leads to better recognition of problems, but does not support the development of adequate solution strategies.

### Introduction

Why do many people find it so difficult to describe their acquirements or, in other words, the things in which they are good at? What they have managed with ease on many occasions and are used to do, turns out to be a problem when it needs to be explained to others. Why can a secretary type, for example, without hardly ever looking at the keyboard, but would not be able to draw the keyboard from memory? The explanation lies in the unconscious application of *knowledge-in-use*. This term is used for practical knowledge about sequences of actions that have been established by repeated utilizations (De Jong & Ferguson-Hessler, 1996; Anderson, 1983). It is embedded in the daily challenges that a person is confronted with, and finds its expression in concrete actions. Especially in large, dispersed organizations, a successful exchange of knowledge-in-use is of importance to ensure equal qualification of their personnel, regardless of distance, and to work successfully.

Knowledge-in-use is highly situational (Greeno, 1998) and in most cases implicit (Polanyi, 1966); that is to say, a person will normally use his or her knowledge-in-use unconsciously and automatically (Anderson, 1983). So both the externalization and internalization of knowledge-in-use are difficult (Smith, 2001; Anderson, 1983). *Externalization* is laborious because people have to be aware of their individual sequences of action. From their own concrete knowledge, they will have to draw general conclusions which can then be presented as abstract knowledge and transferred to other cases. *Internalization* processes are also a complex procedure and not easy to perform in the everyday working life of people who work in the respective field. They will have to transfer information from an abstract level to a very specific and concrete situation in order to make it adaptive.

As both externalization and internalization are indispensable ingredients of *collaborative knowledge building*, there is a strong need to support the exchange of implicit knowledge-in-use by a common knowledge base and, in this way, to enable a collaborative knowledge evolution. I assume that so-called *patterns* can support this exchange of knowledge by guiding the process of externalization. A pattern provides a structured input format and, according to Alexander (1977), the elementary form of a pattern structure consists of a name (short description for the entire pattern), problem (describes the question that could be solved by using the pattern), context (describes in which situation one may use the pattern), forces (competing requirements) and solution (tested in practice in a variety of different cases with similar problems). Depending on the field of application, these categories may be renamed. This structure serves, so to speak, as a scaffold to externalize one's own knowledge-in-use, and make collaborative knowledge building possible.

### Pattern Approach

When experts face a problem, they will resort to solutions that have been applied to similar problems in the past. They may refer to their own experience and re-use what they have found to be an adequate strategy of solving the problem. The invariant aspects of this solution structure, abstract fragments of individual cases, can be considered as a mental pattern. This unchangeable structure is based on specific problem situations, and the result of repeatedly applying a procedure of abstracting single experiences. These have mutually been applied to different problem situations and are applicable in various contexts. Possessing knowledge of this structure is what distinguishes an expert from a novice (Kohls & Scheiter, 2008). But often such knowledge-in-use is only available in implicit form. This means that experts may resort to this knowledge, but are unable to externalize how the problem and its solution corresponded to each other. The aim of the pattern approach is to reduce these complications by externalizing knowledge-in-use and making this knowledge available to others.

The pattern concept is derived from architecture and was originally based on Christopher Alexander's idea to collect samples of good practice as problem-solving examples for the purpose of designing houses and streets by the respective communities (Alexander, 1977). The concept of a 'good practice collection' has also



been implemented in the fields of object-oriented software development (Beck et al., 1987; Gamma et al. 1995; Schümmer et al., 2007) and e-learning (Niegemann & Domagk, 2005).

A classical pattern is characterized by a top-down process: experts produce various patterns about a special topic and make them, as some kind of a manual, available to novices. In addition, there is the idea of a *pattern 2.0* that uses Web 2.0 technologies (e.g. a *wiki*) to enable collaborative knowledge evolution between inexperienced people. Wikis are compilations of web sites that are interconnected via hyperlinks and may be edited by anyone who is interested (Cunningham & Leuf, 2001).

In this context, patterns support knowledge building processes in the following way:

- a) People write down some of their own ideas and experiences in a wiki,
- b) others take them up,
- c) they may then change their practice in line with these new ideas and influences and, finally,
- d) based on their own experience, they can edit the wiki and evolve the original author's pattern to a more abstract description that may be adopted in other situations with similar problems. So a pattern is rather a product of common ideas and a reflection of first experiences than a manual from some expert.

The co-evolution model by Cress and Kimmerle (2008) explicates that processes of externalization and internalization will lead to a mutual development of the individual knowledge-in-use of the pattern authors, and of a collective knowledge base created by all authors. Based on the co-evolution model, I expect that patterns are an effective tool for an improved exchange of knowledge-in-use and collaborative knowledge building, as patterns support reciprocal reflection and improvement of individual patterns by all authors.

To understand pattern-based knowledge building, I will focus on three relevant aspects: externalization of individual knowledge, internalization of knowledge, and evolution of knowledge.

### Patterns and Externalization of Knowledge

Based on *a priori* defined categories, people should externalize their knowledge with the help of patterns. The inherent structure of the patterns will guide the externalization process and help practitioners to understand which information other practitioners will need to utilize the idea. The aim is to write a report of one's own experiences, to identify possible problems together with solutions, and to make it adaptable by others.

Writers are guided, during the act of composing their texts, by distinctive processes of (among others) their own long-term memory and individual writing processes. Retrieving information from the implicit part of one's own long-term memory is a difficult process, because one has to become aware of one's own knowledge, in order to be able to externalize it effectively (Flower & Hayes, 1981; Anderson, 1983). Research on representational guidance has shown that people will process represented material in a more intense way if they get it in the form of graphs or matrices, instead of an unstructured text (Suthers, 2003). Applied to the pattern concept, representational guidance would imply that the inherent structure of patterns will guide and support practitioners when they write down their own good practice.

### Patterns and Internalization of Knowledge

According to Kohls and Scheiter (2008), patterns may exist in the form of mental representations. Such patterns in mind will include a problem-solving schema, which activates adequate solution structures when a known problem has been recognized. Well documented patterns contain reflections on tested solutions, document the structure of the schema, and illustrate their points on the basis of selected examples. So patterns may help to find the solution of a similar problem, and facilitate in this way the adaptation of some other knowledge-in-use (Anderson, 1983; Kohls & Scheiter, 2008).

### Patterns and Collaborative Evolution of Knowledge

I assume that patterns support the collaborative evolution of knowledge-in-use, because a) patterns may facilitate the process of becoming aware of one's own sequence of action, b) patterns may deliver an adequate structure that can improve systematic descriptions of experiences and behavior and make them comprehensible to others, and c) patterns may be helpful in searching for an adequate solution of a current problem.

## **Goals of the Research**

Although it seems to be plausible that the pattern approach is efficient, neither a theoretical framework nor empirical evidence of the mode of operation of patterns exists so far. So the aim of this doctoral dissertation is to close the gap in the pattern concept between theory and empiricism. For this purpose, I have applied the pattern approach to the exchange of knowledge-in-use, and provided a theoretical underpinning of patterns in order to investigate empirically how patterns can support the processes of knowledge externalization, internalization and evolution. Consequently, this project focuses both on a theoretical framework for describing how a computer-supported exchange of knowledge-in-use takes place, and empirical verification of the mode of operation of patterns.

## Background of the Project

This doctoral dissertation is part of the research project PATONGO (Patterns and Tools for Non-Governmental Organizations). In cooperation with the EKD (Evangelische Kirche in Deutschland, i.e. Evangelical Church in Germany) and the FernUniversität Hagen, the idea behind PATONGO is to investigate and optimize the pattern-based exchange of knowledge-in-use in order to improve professional qualification in large, decentralized organizations. The consortium has launched the German-language website [www.geistreich.de](http://www.geistreich.de) as a platform to support collaborative knowledge building between ecclesiastical practitioners by using Web 2.0 technologies.

## Methodology

In the context of this project, I designed a field study on the subject of knowledge externalization, and three laboratory studies on knowledge externalization, internalization and evolution. The field study and the laboratory study on knowledge externalization have already been carried out and are in the process of being analyzed finally. The following paragraphs contain a brief overview of the design and the results of two studies (field study and laboratory study 1).

### Field Study

I conducted a field study with young ecclesiastical practitioners in cooperation with the EKD (Evangelical church in Germany) within the project PATONGO. The participants were asked to describe in a computer-based wiki how they organized a Sunday school for younger children successfully.

### Participants

I performed the study with 46 adolescents at the age of 13 to 21 years ( $M: 16.22$ ,  $SD: 2.76$ ) on the second last day of an one-week advanced training on how to run a Sunday school (34 of these were female). On average, the youths had already had 24 months experience ( $M: 23.89$ ,  $SD: 24.86$ ) in this type of voluntary work.

### Design

To examine the impact of patterns on the externalization of knowledge-in-use and, consequently, on collaborative knowledge evolution, the participants were randomly assigned to one of two conditions to describe their knowledge-in-use about organizing a Sunday school for younger children. Either they were asked to give a *description based on a structured pattern* (the categories were defined a priori by me) or an *unstructured description*. All participants of both conditions had to describe their Sunday school in a computer-based wiki. Both groups consisted of 23 participants and sat, separated from each other, at two different tables. The experiment was based on a single-factor between-subject design (externalization of knowledge-in-use either in a description based on a structured pattern, or in an unstructured description).

### Procedure

All participants passed through 3 phases:

a) In the 15 minute *team phase*, I grouped the participants in pairs, consisting of one participant from the pattern condition and one from the unstructured condition. So one “pattern” participant and one “unstructured” participant, as a pair, had to develop a concept for a Sunday school. The participants were encouraged to refer to previous sequences of action which they already experienced while organizing a Sunday school. The idea was that by going through a team phase, it would be easier for the participants to generate ideas and to discuss their possible implementation.

b) Afterwards, in the *individual phase*, each participant was asked to document the planned Sunday school individually in a separate wiki. The participants from the pattern condition were asked to use given categories for their descriptions, while participants from the unstructured condition wrote down their descriptions in an empty wiki without categories.

c) Finally, all participants were asked to read, comment on and to edit the wiki of another member of their group in the 30-minute *feedback phase*. A “pattern” participant read the wiki written by another “pattern” participant, and an “unstructured” participant read the wiki of another “unstructured” participant. They were asked to add comments and suggest improvements, ask questions if anything was unclear, or complete the description if required.

As dependent variables I measured, on the one hand, the quantity of problems, solutions and references between problem and solution that had been mentioned. On the other hand, I measured collaboration and comprehensibility of the descriptions by analyzing the comments and edits in the wiki.

### Results

First results of the *field study* show that pattern descriptions contained more implicit problems than unstructured descriptions – problems that were not mentioned directly in the instruction for the participants ( $M_{patterns}=1.04$ ,  $SD=0.83$ ,  $M_{unstructured}=0.26$ ,  $SD=0.69$ ,  $t(44)=3.49$ ,  $p=.001$ ). But patterns did not seem to support the

externalization of solutions and references between problems and solutions. Furthermore, I did not find any differences concerning the editing behavior between participants who had written pattern descriptions and those who had written unstructured descriptions.

## Experiments

I conceived separate laboratory studies on externalization, internalization and evolution of knowledge-in-use. For these laboratory studies, I could not work with real practitioners, because it is barely possible to standardize different backgrounds and degrees of expertise and to ascribe a possible effect to the influence of a pattern. So all three studies concern the domain *first aid* and are carried out with inexperienced participants.

This domain was chosen to standardize the procedure of the experiment. The idea was that all participants of the studies should not have any significant prior knowledge of first aid, and train the same first aid measures. A first aid doll with integrated software was used to ensure that the participants' performance could be analyzed accurately. First aid appears to be a suitable domain in this context because it allows participants to acquire new knowledge in a relatively short time and in an implicit way, just by practicing and without explicit facts. Furthermore, the idea was to initiate a problem-solving process that guarantees abstraction of a variety of different situations. This allows to capture the central idea of the pattern approach: that the invariant aspects of different situations are contained in a common, abstract description, with the aim of making it adaptive to other situations with similar problems.

### Study 1: Knowledge Externalization

62 subjects at the age of 19 to 50 ( $M: 25.58$ ,  $SD: 6$ ) participated in the study on the externalization of knowledge-in-use (40 were female). The participants had to be German native speakers without any substantial background knowledge of first aid.

In the *training phase*, the subjects were asked to try to understand two different situations of accidents; their difference was that different measures had to be taken after arriving at the place of the accident. Going through two different situations – allowing some degree of abstraction – was thought to be better than passing on knowledge of just one isolated case. Then, after arriving at the place of the accident, the participants had to perform a cardiopulmonary resuscitation with the first aid doll. The measures for cardiopulmonary resuscitation were identical in both types of accidents. The participants did not receive any information on the essential measures after arriving at the place of the accident and on the correct application of cardiopulmonary resuscitation before and after the training phase. Instead, they were told to train these measures by “trial and error”, and received feedback if their measures were harmful to the victim.

During the following *externalization phase*, the participants were asked to document the measures had to be taken after arriving at the place of the accident in one description (description 1), and the cardiopulmonary resuscitation measures in a second description (description 2) – either in a wiki-based pattern (group 1) or in an unstructured wiki (group 2). Thus, the experiment was based on a mixed design with the type of externalization (pattern *versus* unstructured) as between-subjects factor, and type of measures (measures after arriving at the place of accident *and* cardiopulmonary resuscitation measures in two descriptions) as within-subject factor. It was only after the training phase that the participants were randomly assigned to one of two externalization types (pattern *versus* unstructured wiki).

As dependent variables, I measured again, on the one hand, the quantity of mentioned problems, solutions and references between problem and solution. On the other hand, I measured the correctness of the descriptions.

First *results* of the laboratory study show that the pattern descriptions contained more explicit problems than unstructured descriptions – problems that were relatively obvious in the accident situation ( $F(1, 62)=4,6$   $p<.05$ ). Again, patterns did not seem to support the externalization of solutions and references between problems and solutions. Furthermore, the unstructured descriptions were, in terms of content, more correct than the pattern descriptions ( $F(1, 60)=5,1$   $p<.05$ ). Further analyses will address a deeper, qualitative approach to classifying different types of problems and different solution strategies in the descriptions of knowledge-in-use.

### Studies 2 & 3: Knowledge Internalization and Evolution

The studies on internalization and evolution of knowledge-in-use will be also carried out in the domain of first aid.

In study 2, the participants will first have to read wikis with information about measures after arriving at the place of the accident and cardiopulmonary resuscitation measures, either in a pattern or in an unstructured wiki. Afterwards, they have to apply the new knowledge to different accident situations and, again, they will only get feedback if their measures would be harmful to the victim. As dependent variables, I will measure the quality and correctness of their performance at the place of the accident and with the first aid doll.

In study 3, the participants have to edit and evolve an existing wiki (before and after a training phase) with information about measures after arriving at the place of the accident and cardiopulmonary resuscitation

measures, either in a pattern or in an unstructured wiki in groups. As dependent variables, I will measure the quality of the edits in the wiki.

## Current Status

The field study and the laboratory study on externalization of knowledge-in-use have already been carried out, and laboratory studies 2 and 3 are in the process of planning. Laboratory study 2 on knowledge internalization will be realized until June, 2011.

## Particular Issues of This Dissertation and Further CSCL Research

By the time of the doctoral consortium workshop, I will have finished the analysis of the field study and the laboratory study 1 on knowledge externalization, and realized laboratory study 2 on knowledge internalization. So I will be able to present results that can answer the question of what influence patterns have on the externalization and internalization of knowledge-in-use.

At this point, the project of my doctoral dissertation would benefit greatly from a detailed discussion of how patterns can be a useful and successful method of supporting collaborative evolution of knowledge-in-use. Lessons learned during the doctoral consortium workshop could be transferred directly into the conception of laboratory study 3.

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## The Nature of Knowledge Co-construction: Reconsidering Meaning-making of Postings in Online Group Discussion

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**Abstract:** This study attempts to explore the online knowledge co-construction and develop the analytic method of the online learning. Under the situated-context perspective, we try to capture the nature of the discussion process of the online collaborative group in LAIN. We analyzed the episodes of the dynamic group discussion by reconsidering the meaning-making of each posting in order to gain a full contextual understanding of how collective knowledge developed. Our research used “the single posting” and “the whole thread” as the units of the analysis, then to compare and contrast the results of analysis by using two different units of analysis. At the present, using this compare-and-contrast method, we demonstrated that the result of two different units of analysis show the different meaning of how online group members co-construct knowledge.

### Goals of the Research

In this research, we focus on the knowledge co-construction and the analytic method of the online-learning. Under the sociology perspective, we care about the situated-context process of the learning. We address some main research goals as following.

1. To identify the role of the member and re-interpret the meaning of the each posting in the group discussion under the two different units of analysis — “the single posting” and “the whole thread”;
2. To develop the analytic method of the knowledge co-construction in the online group.

### Background of the Project

Many researchers concerned about the elements and the quality of the knowledge co-construction. First, rather than strive to understand the process by which knowledge co-construction developed, most previous studies on knowledge co-construction attempted to investigate the elements of knowledge co-construction(e.g., Scardamalia & Briereter, 2006; Dennen & Wieland, 2007; Jeong & Chi, 2007; Hmelo-Silver, 2006; Chiu, 2008; Stahl, 2008; Zhou, 2009). Second, many researchers have devoted a great deal of effort to analyzing the quality of knowledge co-construction(e.g., Suthers, Dwyer, Medina & Vatrappu, 2007; Jeong & Chi, 2007; Diggelen, Janssen, & Overdijk, 2008; Cakir, 2009; Reimann, 2009; Zhou, 2009; Stahl, 2010).

Along with this trend of research approach, our analytic method focuses on the situated-context process of knowledge co-construction in heterogeneous online group discussion. We analyze the discussion threads in LAIN (the Learning Atmospheric Sciences via InterNet). To differ from the related literature, we try to use both the “single posting” and “the whole thread” as units of analysis to analyze the same dataset in order to compare and contrast the distinct differences found in capturing the nature of knowledge co-construction between both units of the analysis.

### Methodology

#### The Context

487 voluntary participants attended a 6-week inquiry learning in LAIN. The total of group is 82 groups which 5~6 members consist in one group.

The members of group C2 were selected to be our research subjects. The C2 group consisted of 6 members whose postings totaled 389 and whose online presence frequency totaled 526 (Table 1). The main topic of the C2 group discussion was “Fog”.

Table 1: The frequency of postings and online presence totals of C2 group members.

ID	Posting	Online
010124	150	182
Milkbottle	123	119
Cathyjudy	53	94
Icebox	34	60
Snowlove	28	70
Beer	1	1
	389	526

Since we were interested in how knowledge co-construction developed, we focused on the longer threads, and chose the 15<sup>th</sup> as the sample discussion thread. The 15<sup>th</sup> thread consisted of 69 postings which posted by the 4 members during the second week. Icebox and Beer had not participated in this 15<sup>th</sup> thread. The long thread provides us a better opportunity to discover the progress and the dynamic interaction in the C2 group discussion.

### Data Collection and Analysis

The data log of the discussion forums served as the main resource of data analyses. Data were analyzed to determine each member's participation level and learner-role behavior. In addition to the frequency of total postings and weekly postings, and the timing of the postings; the content of the postings, the interrelationships between them, and the weekly diary of inquiry process were also collected. Two kinds of unit of analysis were used: "the single posting" and "the whole thread".

First, the "single posting" was used as the unit of analysis to recognize and identify the level of group members' role-behaviors. We adopted Waters and Gasson's (2006) approach — "the classification of the primary learner-role behaviors" — to examine the contribution of the participant's behavior in the online forum. The eight learner-role behaviors are: Passive-learner, Knowledge-elicitor, Contributor, Vicarious-acknowledger, Closer, Facilitator, Initiator, and Complicator (Table 2). The classification further provided a framework for three levels of involvement: participation, involvement, and social engagement. This classification was accomplished by 1) identifying the contribution of each posting through comparing the relationship of prior postings to the current one in order to recognize the level and the contribution of the posting, and 2) counting the classification of each posting of each group member, and 3) selecting the highest frequency as the most fitting classification to define the participation level of each group member.

Table 2: The classification of primary learner-role behaviors.

level	Form of Behavior	Milkbottle	Cathyjudy	010124	Snowlove
I. Participation	Passive-learner				
	Knowledge-elicitor	1	3		
	Contributor			13	*
II. Involvement	Vicarious-acknowledger	1	1	1	
	Closer	7		1	
III. Social engagement	Facilitator	19	*	8	*
	Initiator	2			
	Complicator				
	Total	30	12	16	4

PS. The result of the classification of each member is indicated with \*.

From the results showed in Table 3, most of the members fell into the *III. social engagement* level. Milkbottle and Cathyjudy were classified as the *Facilitators* and Snowlove as the *Complicator*. 010124 was the only person to be classified as the *Contributor* and fell into the *I participation* level. It seemed that Snowlove, Milkbottle and Cathyjudy made a higher level of contribution to the group discussion, while 010124 was deemed to have contributed to this group at a relatively superficial level. Interestingly, although 010124 was the most active person in this group in terms of the number of postings, the nature of her postings in thread #15 was more that of a contributor.

In addition to using Waters and Gasson's approach, we purposely reexamined the contribution of each participant by using "the whole thread" as the unit of analysis (Figure 1). In this way, we were able to trace the evolution of the whole 15th thread by referring to both the backward and forward postings and by selecting isolated postings with similar focus within the thread. The time dimension emerged as a pivotal issue to deal with in knowledge co-construction.



Figure 1. The Analytic Structure for "The Whole Thread" As the Unit of Analysis.

In order to represent the meaning of every "single posting" in the accomplishment of knowledge co-construction in online discussion, domain experts and learning scientists collaboratively analyzed the 69 postings with these characteristics in mind: 1) the depth of domain knowledge of the posting, 2) the evolution of the concept's physical property, 3) the flow of the group discussion, 4) the interrelationship between the

postings, 5) the participation features of the group member, 6) the timing of the posting and the atmosphere of the group discussion, and 7) the nature of the response of group members. The results of the second approach provide a distinctively different picture of group knowledge co-construction from those of the first approach—but these two viewpoints are dialectically interrelated.

### Current Status, Preliminary Results or Results of Pilot Work

At the present, we have new meaning-making of postings in online group discussion by comparing and contrasting the result of “the single posting” and “the whole thread” as the unit of analysis. The results identified three critical moments (Table 3):

Table3: The result of “the single posting” and “the whole thread” as the unit of analysis.

moment	the “single posting”	“the whole thread”
confusion and hesitation	The progress of the group discussion had gotten into a confusing condition	The group members were simply waiting for next opportunity to clarify the problem.
from stick around to move forward	The group was engaged in a warm and well-focused atmosphere	Although the two <i>Facilitators</i> actively developed their ideas and presented a sustained discussion, the discussion was not really making further progress and had lapsed into stagnation. Moreover, it was the <i>Contributor</i> who eventually advanced the group discussion “from stick around to move forward”
making justification and breaking through	The <i>Complicator’s</i> opinion was more powerful and the <i>Contributor’s</i> posting weaker in the group discussion	Nobody but the <i>Contributor</i> cared about the <i>Complicator’s</i> opinion. Again, the <i>Contributor</i> justified and supported the correctness of the <i>Complicator’s</i> opinion by copying and pasting. In this process of justification, the <i>Contributor</i> clarified misconceptions in the group discussion, and affected the direction of the group discussion.

Our study showed some implications for analytic methods to examine knowledge co-construction. The findings presented that by using “the single posting” and “the whole thread” as the unit of analysis, we demonstrated that most of the meaning differed from that determined before, and that the classification of primary learner-role behaviors was modified.

### Discussion

In this study we have discovered some interesting ideas and questions which are worthily to discuss in this workshop and are stated as follow:

1. What is the key factor affecting the knowledge co-construction of online learning discussion?
2. Does the different feature of forum need the different analytic method?
3. How to identify the quality of knowledge co-construction in the online learning group?
4. As far as we know there are some limitations presented in this study, such as the sampling of the group, and the sampling of the thread. We consider the situated-context process not just present into one thread, it presents across many threads constitute the process of the group discussion during one period of time. So, we concern about how to analyze the process of the knowledge co-construction by using “across threads” as the unit of analysis.

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## Appendix Data collection

No.	ID	Protocol
#11	Milk	(.....)I have an idea about the hypothesis: Fog occurs in the interface of warm and cold air masses. When atmospheric convection is not efficient, the cold and warm air masses come in contact with each other.
#12	Cathy	What does it mean that atmospheric convection is not efficient? Does it mean there is no wind??
#13	Milk	It might not be possible that there is no wind when cold and warm air contact each other in an air mass within the specific area. I don't know. Can anyone respond to this?
#14	010124	No matter whether it is breezy or windy, lower atmosphere is always flowing. The solar energy is the source of all activities in the atmosphere. The air is heated, expanding and drifting upward and the low air occurs at the surface. It is impossible to have no wind because warm air goes up; cool and height-density air replaces the warm air and thereby generates the wind. Therefore it is not possible to happen in a situation with no wind.
#16	010124	I don't know if my response was correct. Keep thinking about it.
#31	Cathyjudy	The example that the car and the glasses should not be related to the concept of convection.

No.	ID	Protocol
#37	010124	Fog occurs more easily in a low-lying area!!!
#38	010124	Fog occurs over the land more easily than over the sea.
#39	Milk	Low-level cold air should be left behind by the cold front, so it has not enough energy to raise warm air up.
#40	010124	Fog takes place at night easier than during the day
#41	Milk	010124! Give the reasons of your hypothesis or you will not be able to convince anyone.
#42	Milk	Rain in Spring is too light to be felt. Is it a kind of drizzle?
#43	010124	Wind at high altitude is stronger than at lower altitude, so I proposed the first hypothesis. Wind over the sea is stronger than over the land, so I proposed the second one. The reason of the third one is that wind is always stronger during the day than at night.



No.	ID	Protocol
#48	Cathy	<b>【According to #15-42】</b> <i>According to #15-42</i> According to 010124, can we summarize them all into a hypothesis? The occurrence of fog is related to wind, because only one key point that 010124 mentioned is wind.....

No.	ID	Protocol
#45	Snowlove	This is used data..... I thought radiation fog took place on land mostly and the weather must be less wind....
#46	Snowlove	advection fog is not restricted by wind speed, but the advection of warm and wet air.....
#47	Snowlove	Maybe other teams study radiation fog and advection fog, so can we start from another point of view, like looking for some materials of other kinds of fog, then discussing?
#48	Cathy	<b>【According to #15-42】</b> <i>According to #15-42.</i> According to 010124, can we summarize all into a hypothesis? The occurrence of fog is related to wind, because of only one key point that 010124 mentioned is wind.....
#49~50	Milk	The conditions of formation of fog: 1. low temperature, 2 high humidity, 3. less wind, and condensation nuclei.
#51, 52, 55, 57~60	010124	<b>【frontal fog, fog】</b> , <b>【fog】</b> , <b>【Upslope fog】</b> , <b>【Spring fog in early morning is a sign of clear sky】</b> . <b>【Summer fog in early morning】</b> , <b>【Heavy rain in the afternoon】</b>
#53	Milk	<b>【Frontal fog, fog】</b>
#62	Cathy	<b>【The main hypothesis】</b> When the cold and warm air contact each other, fogs take place at where the large temperature difference, more humid warm air, and more condensation nuclei. I specially point out the humidity of warm air.....
#65	Milk	<b>【The main hypothesis】</b> In nature, cold air is below warm air when cold and warm air contact each other. A big temperature difference means the difference between the temperature of cold air and warm air. More temperature difference, suitable wind speed, higher humidity and more nuclei in the air, then fog forms easily.
#67	Milk	<b>【The main hypothesis】</b> Humidity of warm air
#68	Cathy	<b>【The explanation for the main variable】</b> The main variable is not just humidity, but the humidity of warm air. If the humidity of warm air is not high enough and the saturated water vapor pressure becomes lower, it does not reach saturation. (.....)

## Fostering Computer-supported Knowledge Building through Formative Assessment among Chinese Tertiary Students

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**Abstract:** This study aims to design, implement and evaluate a computer-supported collaborative environment, augmented with formative assessment, to foster learning, collaboration, and academic literacy among Chinese tertiary students. The framework of the study is premised on the social constructivist learning theories, with specific focus on the knowledge building model (Scardamalia & Bereiter, 2006). The study adopts a quasi-experimental design, which intends to investigate a number of interrelated questions from the learning-sciences perspective, including the effects of the designed knowledge-building environment; how students make change towards deeper conceptions and knowledge-building processes; the role of formative assessment in the changing process; how classroom processes and discourse mediate knowledge building processes; and the nature and process of knowledge building inquiry and discourse. To answer the questions, data will be collected from questionnaire survey, individual and focus group interviews, students' academic tests results, reflection diaries and portfolio, classroom observations, students' written notes on Knowledge Forum.

### Goals of the Research

The research is to design, implement and evaluate the nature and effects of a computer-supported collaborative inquiry-based learning environment on academic literacy, conceptual understanding, and higher-order competencies among first year Chinese tertiary students. Specifically, The first goal is examine whether knowledge building model (one of the forerunners of CSCL) and formative assessment would enhance academic literacy and conceptual understanding and elicit changes in students conception of leaning, assessment and collaboration; the second goal is to investigate students' understanding and to examine how they were able to make changes in computer-supported collaborative knowledge building; the third goal is to examine the dynamics of formative assessment and the role of knowledge building principles, including both online and classroom processes, in scaffolding individual and collective knowledge building; and the fourth goal is to examine the nature and process of knowledge building inquiry discourse on Knowledge Forum (a computer-based platform specially designed for knowledge building).

### Background of the Project

As recent reform in Chinese higher education is geared to honing students' overall quality, including their collaboration and knowledge-creation competence, there has been increasing interest in finding pedagogical models and practices that suit the needs of the 21<sup>st</sup> century education. This study employs the theoretical framework of knowledge building to investigate the development of conceptual understanding and collaboration amongst Chinese tertiary students.

The contemporary learning theories emphasize the social and collective nature of learning (Bransford, Brown et al. 1999) and parallel to this trend of socio-constructivism witnesses a paradigmatic shift from a testing culture to an assessment culture. In other words, learning is now conceived as a collaborative endeavour (Cummins, 2002), and assessment, especially formative assessment should be an integral part of the instructional process (Shepard, 2000) and be aligned to enhance learning (Biggs, 1999; Black and Wiliam, 2004; Broadfoot 1996; Rushton, 2005). As schools around the world setting goals of increasing student access to computers and the Internet, CSCL has emerged as a new theoretical paradigm of learning (Stahl, 2000) and is designed to address the challenge of combining computer support and collaborative learning to effectively promote learning.

However, although the key focus in paradigms of learning has now turned to the social and collective aspect, important questions as how to develop a social constructivist classroom, how to identify, assess, and scaffold collaboration remains to be investigated. There is in general a lack of alignment in learning, assessment, technology and collaboration in higher education. Many researchers in higher education have kept working on assessment; few of them are now examining assessment for learning in technology-enhanced environment. Likewise, a lot of researchers in technology have designed wonderful environments; but they are relatively less familiar with theories of learning and assessment; so often technology is not well informed. In addition, although there are much calling for developing higher-order thinking and inquiry in higher education reforms across the world, very few research on how to assess those higher-order thinking competencies has been conducted. Therefore, much effort is needed to integrate assessment, technology, learning and collaboration to

examine assessment for learning, thinking and collaboration in technology-enhanced and new learning environments.

The theoretical framework of this study is premised on knowledge building model. Many empirical studies have been conducted to demonstrate the knowledge building effects on students' learning outcomes as well as their higher-order capacity, including knowledge-creation. Scardamalia et al (1994) described a CSILE intervention study where a community of learners could be extended beyond the bounds of the classroom walls using computer technology for facilitating asynchronous questions, suggestions and answers between students and experts. Caswell et al (2001) concluded that the integration of online and offline interaction affected the learning environment, changed the structure of the learning activities and fostered thinking and learning skills amongst Grade 5 and 6 students. Hewitt (2002) reported that students migrated from focusing on tasks to focusing on understanding with a change in pedagogy. Later studies (Lee et al. 2006; van Aalst and Chan, 2007) suggested portfolio assessment help characterize collective knowledge advances and foster domain understanding. Sun et al, (2009) showed that knowledge building can help students improve their literacy and reading, and Zhang et al. (2009) study revealed continuum progression of collective cognitive responsibility, knowledge advancement, and dynamic diffusion of information among young students.

However, most of the studies are conducted in the elementary or secondary schools, and in the science discipline. As Scardamalia (2004) mentioned that *Knowledge Forum(building) must apply to knowledge builders of all sectors, ages and cultures*, more empirical studies are needed to see how knowledge building can be fostered and assessed in other different settings, for example, in higher education and in other subject areas other than science. Despite numerous studies have demonstrated positive effects of knowledge building in student learning conceptions and learning outcomes, there is not much work on how formative assessment can scaffold and characterize knowledge building. In addition, there remains an interesting line of inquiry as how classroom processes can mediate and facilitate knowledge building inquiry, integrating online and offline learning. Although knowledge building model has been implemented in education almost all over the world, it is still quite new to Mainland China and it is worthwhile to see how Western constructivism is related to Chinese learners and the role of formative assessment can play in the knowledge building context.

Therefore, this study will examine the constructive alignment of learning, assessment and collaboration in a computer-supported collaborative learning environment, with the following interlinked research questions formulated: 1) What are the effects of the designed learning environment on students' conceptions of learning, assessment, collaboration as well as academic performance? 2) What are the changes and how do students make changes towards deeper conceptions and knowledge-building processes? What are the roles of formative assessment in this changing process? 3) How do classroom knowledge building discourse mediate and facilitate knowledge building processes, integrating online and offline learning? and 4) What are the nature and process of knowledge building inquiry and discourse?

## Methodology

Participants of the study are two intact classes of first year tertiary Sino-British program students in a renowned business-and-economics-oriented university in Shanghai, China. This study uses a quasi-experimental design examining the knowledge building environment with principle (**KBP, n=30**) and the non knowledge building environment (**NKB, n=30**). KBP environment in this study is characterized by knowledge building theory, pedagogy and principles, formative assessment, and the technological platform, Knowledge Forum. NKB environment refers to the teaching environment which is usually composed of teacher's lecture and students' discussion. However, due to the school policy and to examine more closely whether it is merely the novel effects of inclusion of technology or deeper impacts via knowledge building theory-pedagogy-technology, NKB environment is also supported by Knowledge Forum. Both classes will be taught by the same teacher and the course is titled *Introduction to Business*. Lessons are conducted in the medium of English and students write notes on KF after class.

**Implementation of the learning environment.** 1) *Forming a collaborative learning culture.* In the first few sessions, students will be provided with learning experiences which shall familiarize them with the technology and acculturate them into the practices of collaborative inquiry. A focus is placed on making ideas public. 2) *Developing knowledge-building inquiry.* The course curriculum includes some big, core ideas. As with knowledge building pedagogy, students through face-to-face and online discourse, will elaborate what they need to know about these themes, to set forth their theories, to search for useful resources, and to probe and explore the answers in a cyclical and deepening way. 3) *Emergence and rise-Above.* Students have agency and they can define goals and activities as the questions emerge in the classroom or online discussion. The teacher becomes a co-inquirer of knowledge. Students work on inquiry threads themselves and the teacher, acting as a member of the knowledge building community, scaffolds the discussion towards a continuous rise above way. 4) *Formative assessment.* Assessment sits at the core of the study. Formative assessment is to scaffold learning as well as characterize collective knowledge. Classroom reflective assessment and electronic portfolio assessment will be implemented. Student reflective presentations are designed to foster social meta-cognition and bridge the

gap between classroom learning activities and knowledge forum activities. E-e-portfolio assessment is to assess both individual and collective aspects of learning and give student more agency in assessing their own learning (van Aalst & Chan, 2007). Students are provided with conceptual change scaffolds, “My initial idea”, “What we discussed”, and “What I think now” in selecting notes and giving explanations. 5) *Knowledge building discourse scaffolded by knowledge building principles*. Drawing insights from knowledge building studies, 4 knowledge building principles are to be used in this study, namely, epistemic agency, improvable ideas, community knowledge and collective responsibility, and constructive uses of authoritative source of information. Taking advantage of the embedded assessment tools such as ATK or Applet, this study will also try to explore the principle of embedded, transformative assessment. Knowledge building principles will permeate different phases. A principle-based design is undertaken to scaffold knowledge building discourse and inquiry.

**Data sources and proposed analyses.** Data from multiple sources will be collected, including a questionnaire survey on beliefs about knowledge and learning, learning approaches, conceptions of collaboration, and students’ preference on assessment. Domain tests and individual and group report writings are used to examine students’ academic literacy. In addition, individual interviews, focus group interviews, knowledge forum notes, classroom observations such as audio and video clips, and teacher’s reflection journals will be employed to examine the changing process of students’ engagement in knowledge building and the dynamics of knowledge building classroom. Both quantitative and qualitative approaches will be used. Quantitative analyses include pre and post questionnaire measuring learning conceptions, processes, collaboration and assessment perceptions for the two environments. Qualitative analyses of interview results and classroom processes and discourses will be performed to examine and categorize the process of changes from the perspectives of the students, artefacts, and classroom dynamics. For example, interviews questions may include, “I have noticed that you have written a lot of KF notes, why are you doing that? do you find it help?”; “What do you think are good KF discussions?”; “Do you find something you feel happy/interesting about working on KF”? “Do you think you have solved some problems?”; “Do you think we have knowledge advances in the KF inquiry?”

ATK (Analytical Tool Kit, measurements for knowledge building such as participation and collaboration) and SNA (Social Network Analysis, measurements for knowledge building such as community awareness and connectedness) indices will be included. ATK measures such “notes created” “notes linked”, “notes read” and “notes revision” will be used to perform correlation analyses to examine whether KF usage can predict students’ academic performance, domain understanding, and knowledge building inquiry. So will SNA measures such as “read density” and “build-on density”. To characterize the collaborative inquiry forum discourse, this study will categorize the discourse into “inquiry threads” based on principal problems addressed by the community (Zhang et al. 2007). A coding scheme will be developed for content analysis of discourse in each thread. Drawing insights from van Aalst’s (2009) model of knowledge sharing, knowledge construction and knowledge creation, several main codes such as social dynamics, mate-cognitive move, epistemic questions, epistemic explanations, and meta-discourse will be analyzed. Indicators for epistemic explanations may include, for example, simple explanation (with little relevant information), elaborated explanation (with constructive use of information) and meta-explanation (synthesizing different views in previous discussion and rise above).

## Preliminary Results

The study is still at an on-going process. Both groups of students are writing a large number of notes. A code scheme is not yet developed. However, there might be a hypothesis that students in the KBP environment generate notes which are more knowledge construction, or opportunistically, knowledge creation oriented; while students in the NKP environment may produce notes which show more evidence of knowledge sharing, less evidence of knowledge construction or knowledge creation.

I include some examples of students doing reflective presentation, and students articulate their interaction with knowledge forum.

One of the girl students, while in the KBP classroom doing her reflective presentation on students’ KF activities, used a lot KB (meta-) discourse, for example:

#1-1 First let us see how much work you have done on the KF on the two points!...

#1-2 But there is still some time that we have a deviation from the core theme ...

#1-3 There are some good KF questions ...

#1-4 Some questions that haven’t been answered yet!...

#1-5 However I hope we can do more on KF: try to find some valuable questions, try to find more authority (authoritative) information, and try to use the scaffold(s) and reference(s).

Students in the KBP environment also reflected their interaction with KF in the kb processes:

#2: I feel bored at the technology at very beginning. But I find it interesting when I was asked to put my investigation results on KF. This helps me in self-exploration study...I read others’ notes and I learn vocabularies, expressions and the way to organize materials... I think the more notes, the better; but I pay attention to quality; I take it seriously when I think I need to articulate my ideas...

#3: ... our thinking is changing everyday. When ideas are put on KF, you can continue to build on...I think I do learn new things from KF, especially new ideas from our classmates. I read KF in recent 2, 3 weeks, I have found, *Liu* has some idea the other day and she built on new notes later on, I would trace her line to see the changing conceptions and follow the in-depth discussion. ...

#4: But when you read other's notes, you feel 'Woow, there is such an event or this is really a new idea'. I do feel the sparkling of thinking moments. Someone says something; the other questions 'Is it the case'? Then the discussion continues... some other one provides new information...I follow the inquiry process...to analyze the problems and new ideas come up..."

### Particular Issues in the Dissertation

At present, this study is still collecting data. Some particular issues include how to develop a coding scheme to categorize the online discourses, particularly related to a field of business studies. In the past, a lot of work has been done in the coding of the science domain, so code categories such as half scientific, scientific, etc. can be employed. Business studies are different, where there is lack of scientific concepts, instead, there may be a lot of idea diversity, newly appeared business terminologies or puzzling business phenomena, so how to put the notes into different level is a challenge. In addition, a sound interview protocol is needed to capture the highpoints of classroom discourses and explain the role of formative assessment in mediating knowledge building.

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# Trust Modeling and Evaluation in Personal Learning Environments

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**Abstract:** The design of effective trust and reputation mechanisms for personal learning environments is believed to be a promising research direction. We propose to investigate personalized trust and reputation models, aiming at agile recommendation of trustworthy people and services to support self-directed learning activities. In this proposal, existing trust and reputation systems are discussed and the particular requirements of personal learning environments are analyzed as well. Furthermore, our preliminary research work is addressed with some encouraging results. Finally, future research directions that could be further explored during the workshop are also discussed.

## Research Goals

Benefiting from the popularity of Web 2.0 social software, interactive information sharing becomes pervasive. For users surrounded by an abundance of information, the challenge now is how to determine which resources can be relied upon and who is reliable enough to interact with. For the purpose of solving this problem, a number of trust and reputation systems have been developed in various platforms, including e-commercial sites, product review systems, and professional communities. As indicated by Josang (2007), trust and reputation measures can assist other parties in deciding whether or not to transact with a given party in the future, and whether it is safe to depend on a given resource. This represents an incentive for good behavior, which thereby tends to have a positive effect on the quality of interaction in online communities.

As a particular support framework for interaction in online communities, personal learning environments (PLEs) embed tools, services, content and people involved in the digital part of the learning process (Casquero et al., 2010; Gillet et al., 2010). It is intended to sustain the new learning mode of “Digital Native” or “Net Generation” (Tapscott, 2009), who are intuitively tech-competent and highly involved in online social communications. Web 2.0 solutions like blogging, tagging, rating and commenting are gradually incorporated into learners’ overall learning ecology, which is believed to increase new learners’ learning incentives and enhance their learning experience (Heiberger et al., 2008). On one hand, these Web 2.0 features enable users to express opinions easily and facilitate accumulating domain knowledge. On the other hand, users’ active contributions produce a large amount of user-generated content, which may lead to information overflow. In such an open learning environment, it is not easy for learners to find suitable people to learn from or to collaborate with. Moreover, the flood of data might bring about the challenge of selecting useful learning resources depending on personal learning goals. Therefore, research efforts are needed to design appropriate trust and reputation mechanisms for personal learning environments, aiming at expertise assessment and quality assurance.

## Research Background

The notion of trust is a complex social concept, which reflects the subjective perception one party holds about another party. It’s asymmetrical, transferable, dynamic, context-dependent, and can be influenced by various factors, such as social rules, personal experiences, rumors, and human relationships (Yan et al., 2008). Compared to trust, reputation is a shared, aggregated belief a group holds about a particular entity. It can be considered as a collective measure of trustworthiness based on the referrals or ratings from members in a community (Josang, 2007).

In order to develop effective trust and reputation schemes, a number of attempts have been made in both literature and practice. On the application level, most social software uses reputation as the main input to trust evaluation. Investigation of trust metrics was conducted for product review sites, professional communities and general knowledge base sites where trust measurement plays an important role in Web-based interaction.

The product review site “epinions” (<http://www.epinions.com>) uses a reputation system that applies to products, shops and reviewers themselves. Members of “epinions” give quantitative ratings from 1 to 5 stars for a set of aspects such as Ease of Ordering, Customer Service, and On-Time Delivery, to shops and products. Members themselves obtain different status like Advisor, Top Reviewer and Category Lead, according to the ratings on the reviews they have written. Additionally, the “ePractice.eu” (<http://www.epractice.eu>) is an online professional community in the domain of eGovernment, eInclusion and eHealth. It uses “Kudos” as a way to acknowledge the activity and reliability of registered members. Each activity a user performs on the portal is awarded a numerical value that is associated to the user’s profile. The higher the total number of Kudos a user has, the more active he/she is. Another example is “Everything2” (<http://www.everything2.com>), a general knowledge base site composed of user-generated content. Users submit various kinds of articles, which can be

voted as “positive” or “negative” by other users. The article keeps track of its total voting scores (reputation number) that can be viewed by the author and all the voters.

It is easy to discover that, most of current trust and reputation systems consider reputation as a global property and use it as the measurement of trust, which makes trust value static even from different people’s point of views. However, people’s trust opinions about a certain party vary because of various personal experiences. In an attempt to solve this problem, many efforts have been made on the academic research level. The representatives of personalized trust models are TidalTrust (Golbeck et al., 2006) and MoleTrust (Massa et al., 2007). TidalTrust builds a trust network by asking user to assign a trust value to another user when the former adds the latter as a friend. A modified breadth first search is performed in the trust network in order to find all raters with the shortest path distance from the source user. Then a rating score for a particular item is predicted by aggregating all those ratings weighted by the trust value of the raters. Finally items with high predicted rating scores are recommended. Similarly, MoleTrust asks user to express how much he/she trust others and therefore constructs the trust network. Both of the two approaches exploit the trust network for a particular user and thus make personalized rating prediction by emphasizing rating opinions provided by trusted users and ignoring those provided by unreliable ones. However, those trust systems without exception need users to specify explicitly whom they trust and how much they trust each other.

The state of the art in trust and reputation systems has been summarized so far. How to extend and improve the existing models in order to comply with personal and collaborative learning requirements is the main focus of our research. Unlike the communities of market economy which concentrate on particular domains, learning communities are multi-disciplinary and multi-dimensional platforms where resources and services are aggregated from heterogeneous sources. It’s essential to evaluate the quality of user-generated content and expertise of unknown parties in given learning context and for particular learning goals. Therefore we propose to design effective and robust trust and reputation mechanisms, facilitating constructing personalized and contextualized learning environment, as well as providing an incentive for good behavior in the learning community. Ongoing research is being conducted, and preliminary results have been obtained. In the following section, the current status of our research will be addressed in detail.

## Preliminary Work

The proposed research has been carried out in the framework of the ROLE European project (Responsive Open Learning Environment), which aims at supporting self-directed learning thanks to innovative Web-based personal learning environments. In this section, the preliminary work of our research is addressed and some encouraging results are shown as well.

In our previous work, a trust-based rating prediction approach is proposed (Li et al. 2010). It relies on the 3A interaction model (El Helou et al., 2009) that is particularly focused on describing and designing social and collaborative environments. A multi-relational trust metric is designed, aiming at measuring the trust relationship between the target user and people in his or her trust network. Rating scores of items associated to a community are predicted using the implicit trust network of a particular user. An evaluation of the approach has been conducted using the dataset of a collaborative learning platform, namely *Remashed* (remashed.ou.nl) (Drachsler et al., 2009).

## Proposed Approach

The trust-based rating prediction approach proposed relies on the 3A interaction model, which is particularly intended for designing and describing social and collaborative learning environments. It consists of three main constructs referred hereafter as entities: **Actors** represent entities capable of initiating an event in a collaborative environment, such as regular users or agents. Group **Activities** is the formalization of a common objective to be achieved by a group of actors. **Assets** represent artifacts produced, edited, shared and annotated by actors in order to mediate collaboration and meet objectives of group activities. They can consist for example of simple text files, RSS feeds, content of wikis, as well as video and audio files. The model accounts for Web 2.0 features: entities can be tagged, shared and rated.

In the 3A interaction model, actions performed by actors result in heterogeneous types of relationships like tag, link, authorship, membership, comment, or rate. Those relationships somehow represent different amount of potential trustworthiness depending on the importance of that particular type of relationship. For instance, the action of Alice joining a group activity called Advanced Algorithms indicates that Alice holds a certain amount of trust regarding to the Advanced Algorithms group activity. Instead of asking users express trustworthiness directly, the trust relationship is dealt with in an implicit way. Considering the 3A entities as nodes and relationships as edges between them, a weighted trust network is constructed, taking into account the importance of relationships.

The basic idea of the proposed trust metric can be briefly described as follows. The trust value that is derived from a particular type of relationship is defined as **Direct Trust**. Let  $R_i$  denote a relationship of type  $i$  existing between a user  $s$  and another party  $t$ ,  $W(R_i)$  denote the weight of relationship  $R_i$ , and  $N(s, i)$  denote

the number of outgoing relationship edges of type  $i$  from the user  $s$ . Then  $DT(s, t)$ , the Direct Trust value of the user  $s$  regarding the party  $t$ , can be inferred as in (1):

$$DT(s, t) = \frac{W(R_i)}{N(s, i)} \quad (1)$$

Besides the Direct Trust, trust could also propagate along the relationship path starting from the target user, as it does in real life. For instance, if Alice trusts Bob and Bob trusts Clark, Alice may have a certain amount of trust in Clark. The trust value that is derived from trust propagation through relationship path is defined as **Indirect Trust**. However, trust relationship is not completely transitive, and it could decay through distance. Therefore, a **Propagation Distance** of trust is introduced to constrain the range that trust is able to propagate (i.e. Trust relationship is unable to extend beyond that distance). Based on the Direct Trust derived from the social relationships and Indirect Trust derived from trust propagation, a trust network of a particular user is constructed within the trust propagation distance.

Figure 1 illustrates the trust network of a user, called Alice. Alice joined David's ski club, David tagged Eva in his photo, and Eva rated Greg's article. The relationship path indicates an implicit trust propagation from Alice to David, then to Eva, and finally to Greg. Similarly, trust also propagates through other social relationships starting from Alice, and a personalized trust network of Alice is generated accordingly.

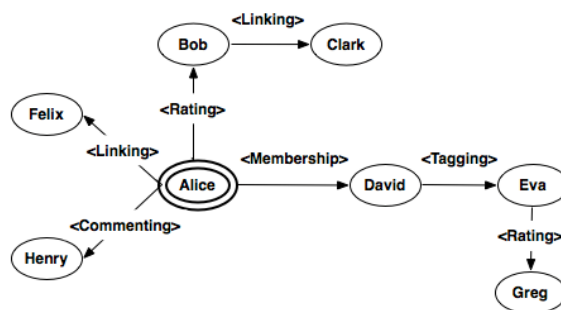


Figure 1. Alice's Trust Network.

Using the Direct Trust value between each pair of entities, Indirect Trust value can be inferred by extending the trust network layer by layer, centered on the target user. The trust values of the user's direct neighbors are computed first, followed by computing the entities at the second distance level. The trust inference process is continuously performed until it reaches the predefined trust propagation distance. The inferred trust value for an entity at a certain distance is the average of all the incoming trust edge values, weighted by the trust value of the corresponding entity that the trust edge is derived from. Let  $s$  denote the target user that lies at the center of the trust network, and  $t$  denote an entity at a certain distance in  $s$ ' trust network.  $E$  represents the set of all the entities  $e_j$  that has a direct trust edge to  $t$ .  $T(e_j, t)$  denotes the trust value from  $e_j$  to  $t$ , and  $T(s, e_j)$  denotes the trust value from  $s$  to  $e_j$ . Then the Indirect Trust value from  $s$  to  $t$ ,  $IT(s, t)$ , is inferred as in (2):

$$IT(s, t) = \frac{\sum_{e_j \in E} T(e_j, t) T(s, e_j)}{\sum_{e_j \in E} T(s, e_j)} \quad (2)$$

For a particular user, the implicit trust values of all the entities in her trust network can be inferred using the multi-relational trust metric described above. In order to eliminate those people who have little trust relationship with the target user, a trust value barrier is defined. The people with trust value lower than the barrier are seen as distrusted and thus are excluded from the trust network. Finally, all people in one's trust network are considered as her trustable people.

For a particular item in the collaborative learning environment, instead of giving a static rating score, a personalized rating score is predicted from the standpoint of the target user using her trust network. The predicted rating score to the item is the average of all the ratings given by the trustable people, weighted by the trust value of those people. Only the rating opinions provided by trustable people of the target user are taken into account, which eliminates the unreliable rating information, improves the quality of rating prediction, and therefore facilitates providing better recommendation and guidance for identifying useful learning resources,



peers and group activities. Considering the timeliness of rating, a time decay function is adopted to all the rating scores, giving higher weight to more recent ones.

## Model Evaluation

For the purpose of evaluating trust-based rating prediction approach, the proposed model is applied on the dataset of the learning platform, *Remashed*. *Remashed* is an informal learning environment that gathers the public items of users' Web 2.0 services such as SlideShare, Delicious, Flickr, or Twitter. The posted items can be tagged and rated. The *Remashed* dataset contains 50 users, more than 6000 contributed items, more than 3000 tags and approximately 450 ratings.

In order to conduct the evaluation, *Remashed* dataset is first mapped to the 3A interaction model. The structure of *Remashed* dataset is relatively simple, composed of two entities: user and posted item. User can obviously be mapped to actor in the 3A model, and posted item can be mapped to asset. However, activity in the 3A model is omitted here since *Remashed* dataset doesn't contain such a structural entity. Based on the user actions in *Remashed* system, there are three types of relationship between users and items: authorship, rating and tagging. Each type of relationship represents a certain amount of trust value and thus will be given different weights when inferring trust.

A target user's trust network is constructed based on the relationships of authorship, tagging and rating. A typical evaluation method for recommender systems, leave-one-out (Golbeck, 2006), is used to perform the evaluation experiment. The basic idea of this method is to withhold a rating given by a user to an item and then try to predict it using the remaining trust network of this user. Then the predicted rating score can be compared with the actual rating score specified by the user. The difference will be considered as prediction error.

Mean Absolute Error (MAE) (Moghaddam et al., 2009) is adopted to measure the deviation of a predicted rating score from its actual rating score. Let  $S$  denote the size of the test set,  $pr_i$  denote the predicted rating score and  $ar_i$  denote the actual rating score, then MAE is calculated as in (3):

$$MAE = \frac{\sum_{i=1}^S |pr_i - ar_i|}{S} \quad (3)$$

In *Remashed* dataset, 12 out of 450 rating records are used as test set, because only a small number of posted items have multiple ratings. During the evaluation, different trust weights are given to three types of relationships in *Remashed* dataset separately. Figure 2 illustrates the deviation of trust-based predicted rating score from the actual rating score, compared to the deviation of simple average rating score. In this case, authorship, rating and tagging are given the weights of 1.0, 0.6 and 0.6 respectively. Maximal trust propagate distance is predefined as 3. As shown in Figure 2, trust-based rating prediction obviously reduces the deviation from the actual rating score. MAE of trust-based rating prediction approach is 0.823, while MAE of average rating score is 0.985 with the rating scale of 5.

Different propagate distances and trust weight settings are chosen for evaluation. The evaluation results show that, the trust-based rating prediction approach has much smaller prediction error than the simple average rating. On this test set, the change of trust weights for relationships doesn't make a significant difference in the results of rating prediction, and trust propagate distance of 2 is the optimal value in general. It indicates that, instead of improving the prediction results, increasing the size of trust network might add noise, which might lead to bigger prediction error.

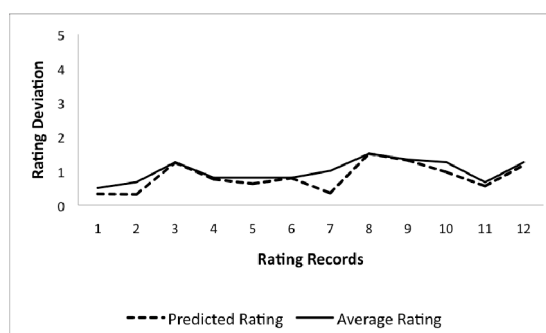


Figure 2. Deviation Comparison between Trust-Based Prediction and Simple Average.

## Future Work at Workshop

Although preliminary evaluation has been conducted, the usefulness and effectiveness of the proposed trust model still need to be further explored. Due to the complexity of the multi-relational trust metrics, designing a usable implementation of the trust model in a real personal learning system could be a challenging topic that needs further discussion at the workshop. Moreover, evaluation methodology through larger dataset and user studies should also be tackled in future research agenda. Another interesting research direction could be to explore agile recommendation of trustable people and resources in personal learning environments, aiming at supporting self-directed learning activities. Last but not the least, since information sharing becomes pervasive in personal learning environments, privacy control over learners' shared online information has been receiving growing attention. Trust-based privacy mechanisms that ensure data sharing among trustworthy parties could be a promising research topic as well.

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## Supporting Progressive Idealization of Physics Understanding through a Mixed Reality Learning Environment

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**Abstract:** This project will examine how mixed reality learning environments can support student learning through coupling physical objects and actions with digital representations. Drawing from theories on the roles of external representation and embodiment in cognition, it will investigate how tightly coupling physical objects and actions with digital representations may help students in constructing their understanding of formal physics concepts, in particular when compared to more traditional physical laboratory environments and computer simulations in science classrooms. This project will also investigate what particular affordances mixed reality learning environments may have for collaboration and group meaning making within inquiry science classrooms. In this submission, I describe the theoretical foundations of this work, the design of a mixed reality inclined plane learning environment for use in a middle school simple machines curriculum, the research methods that will be employed, the current status of the project, and how participation in the doctoral consortium can help to shape this research.

### Goals of the Research

There are a growing number of technologies that combine digital information with elements of the real world. These mixed reality technologies (Milgram, Takemura, Utsumi, & Kishino, 1994) – including augmented reality and tangible interfaces – may be of significant benefit to education (O'Malley & Stanton Fraser, 2005), but we are only beginning to understand how such technologies can affect learning (Marshall, 2007). The overall goal of this research project is to investigate how mixed reality technologies can best be used to support learning, specifically in the domain of physics. This project seeks to investigate whether and how a mixed reality environment can support student learning through coupling physical objects and actions with digital representations and through the *progressive idealization* of the representations offered. In particular:

- How does a mixed reality learning environment compare to separate traditional laboratory and simulation activities in science classrooms?
- Is the tight coupling of digital representations with physical actions and objects important for supporting student understanding?

Further, this project will explore the roles that representational mappings and representational abstraction play within the environment itself, including the location and level of abstraction of individual representations. Across all of these investigations, support for both individual understanding and collaboration will be examined. The project will also move beyond how a mixed reality environment can support initial learning to examine how it can support transfer to new situations and long-term understanding as well.

### Background

A major goal of much of education since Dewey (1938) has been to connect the abstract ideas of the classroom to students' everyday experience. The relationship between everyday experience and abstract concepts is particularly salient in physics education. Despite a substantial body of empirical research, physics remains difficult to teach and to learn, and many students perceive physics as overly abstract and complex (Duit, Niedderer & Schecker, 2007). One issue related to this problem is the use of formal, abstract representations (e.g., vectors, graphs) in the practices of physicists (Duit, Niedderer & Schecker, 2007). Though external representations are essential aspects of human cognition (Zhang & Norman, 1994) and are especially important in the disciplinary practices of scientists (Kozma, 2003), students often have difficulties using external representations. For example, student understanding of representations is often based on surface rather than conceptual features, and students often have difficulties transforming among or translating between representations (Kozma & Russell, 1997). There also appears to be a tradeoff between concrete representations – which are easier to understand and can foster initial learning – and abstract representations that are more difficult to learn initially but can help students apply their knowledge across a greater number of situations (Goldstone & Son, 2005; Koedinger, Alibali & Nathan, 2008).

In addition to the use of formal, abstract representations in physics, a second piece of the gap between everyday experience and formal physics understanding relates to the idealization and decontextualization that constitutes formal physics knowledge itself. Much of formal physics deals with idealized situations (for example frictionless environments in classical mechanics). The differences between the idealized situations and

mathematical models of physics and students everyday experiences of physical phenomenon can lead to many student misconceptions (Duit, Niedderer & Schecker, 2007).

In current physics inquiry classrooms, either physical laboratory environments or computer simulations are designed (in part) to tie the abstract ideas of the classroom to everyday experience. These physical and virtual investigations each have particular affordances and constraints in supporting learning, and both can play a part in the idealization and formalization of physics knowledge. Physical experiments can introduce students to the important conceptual and procedural knowledge of science (Hofstein & Lunetta, 2004), beginning to frame their real-world experience in terms of the formal variables of the domain. Computer simulations can combine multiple representations (verbal, numerical, pictorial, conceptual and graphical) of various levels of abstraction and can allow students to perceive variables and conceptual relationships that are not directly observable in the physical environment (Snir, Smith, & Grosslight, 1993). They can also provide access to idealized situations that would be impossible or impractical in the physical world (Hofstein & Lunetta, 2004). Thus, computer simulations can allow for the idealization of both the representations and situations presented. Movement from grounded to idealized representations and situations may help students to progressively idealize their everyday experience in the physical world toward the formal conceptions of physics. In previous research, our research group has explored the combination of physical and virtual experiments, finding that students learned more from a physical-virtual sequence of experiments than a virtual-physical sequence (Smith & Puntambekar, 2010). A potential explanation is that physical experiments can give students opportunities to gain grounded, physical experience to develop a basic understanding of the phenomena of interest, while the simulations can allow students to test their understanding in idealized situations that are impractical or impossible in the real world.

In our previous studies, although providing both physical and virtual experiments in the classroom supported student learning, these students still had difficulties in coordinating between and making meaning of the data from the two types of experiments. With technological advances in combining digital information with the real world artifacts and actions, there may be new opportunities for combining physical and virtual elements in science laboratory environments. Can mixed reality technologies be used to combine physical and virtual laboratories that take advantage of the affordances of each?

### **Progressive Idealization of Physics Understanding through Mixed Reality**

Within computer simulations of science phenomena, presenting concrete representations of phenomena first, then moving to more idealized representations can support both initial learning and transfer to new situations (Goldstone & Son, 2005). This *progressive idealization* of representations may apply not only to simulation environments, but may be expanded to include physical objects and actions as well. As other researchers suggest, coupling physical objects and actions with digital representations is one area where mixed reality technologies can be used to bridge the “abstraction gap” (Zufferey, Jermann, Do Lenh, & Dillenbourg, 2009) between everyday experience and the abstract, formal understanding of the domain of interest. This research project puts forward a model of progressive idealization from concrete, everyday experience to the abstract conceptions of formal physics, through the *tight coupling* of physical artifacts and actions with multiple digital representations. In this model, augmenting physical artifacts and actions with digital, abstract representations (e.g., graphs and vectors) can begin to formalize students’ everyday experience around the formal variables of physics. By providing representations (both physical and digital) at various levels of abstraction, such a mixed reality learning environment may help students translate or construct references across the physical and digital representations. In terms of physical and virtual laboratory experiments, such an environment would combine the actions and artifacts of physical laboratory environments with the ability to combine multiple representations and explore idealized situations of computer simulations. This model proposes that, through the tight coupling of coupling of physical and digital presentations can progressively idealize everyday experience toward the formal concepts of physics.

As stated above, this project seeks to investigate how a mixed reality environment, through the *progressively idealization* of representations and situations presented, can support students’ abstract conceptual knowledge of physics. In particular, this project will examine how a mixed reality learning environment designed with these principles compares to separate traditional laboratory and simulation activities in science classrooms as well as other approaches to combining physical and virtual elements in science classrooms – for example adding haptic feedback to computer simulations (e.g., Chan & Black, 2006; Jones et al., 2006). The project will also investigate the role of action in developing abstract understanding of physics and the roles that representational mappings and representational abstraction play within the environment itself. Further, this project will explore how a mixed reality learning environment can support collaboration by groups of students, especially when compared to traditional laboratory and computer simulation environments.

## Theoretical Framework

Current work on mixed reality environments and learning often draws from either cognitive science research on external representations or theories of embodied interaction and cognition (O'Malley & Stanton Fraser, 2005). This research project will draw from both of these traditions, highlighting the ways in which representations can support both individual and collaborative learning, and the importance of action in cognition and conceptual understanding.

Some researchers and designers of mixed reality learning environments draw from theories of the functions of multiple external representations (e.g., Ainsworth 1999, 2006), highlighting the ways that spatially and/or temporally coupling representations can influence learners' understanding of individual representations and in turn influence learning. For example, a familiar representation can constrain the meaning of an unfamiliar one that is coupled with it (Ainsworth, 1999). From the perspective of mixed reality designers and researchers who draw from this tradition, mixed reality technologies enlarge the design space by including physical representations as well as digital representations (O'Malley & Stanton Fraser, 2005). Actions with these physical representations can be coupled with digital representations, expanding the range of possible actions and sensory-motor experiences when learning with multi-representational environments. In physics classrooms in particular, coupling familiar, physical objects and actions with the abstract representations of formal physics may constrain learners' interpretation of the abstract representations and help learners to move toward a more abstract understanding of physics. Indeed, other researchers argue that particular mappings between representations and objects or actions can contribute to different levels of abstraction (Price, Falcão, Sheridan & Roussos, 2009). According to O'Malley & Stanton Fraser (2005), "physical activity itself helps to build representational mappings that serve to underpin later more symbolically mediated activity after practice and the resulting 'explication of representations.'"

Beyond influencing learning at an individual level, different representations can have different affordances for collaboration (Suthers & Hundhausen, 2003), and it is possible that this mixed reality learning environment may have somewhat different affordances for collaboration and collaborative learning than the more traditional laboratory and simulation environments that are often used in science classrooms. In a pilot study with 21 middle school students, we investigated the affordances for collaboration of the mixed reality learning environment compared to traditional physical experiments and computer simulations (Smith, Bopardikar & Puntambekar, 2011). We focused in particular on students' joint attention (Barron, 2000) when using physical, virtual and mixed reality laboratory activities. We found that a mixed reality inclined plane environment provided more opportunities for joint attention by students than a physical laboratory or computer simulation, specifically in the number, visibility, and persistence of representations offered that could serve as shared referential anchors for students. One of the goals of this research is to further build from this pilot work to understand how mixed reality learning environments may support collaborative learning.

Because of the additional forms of action and interaction that mixed reality affords, many researchers have also drawn from theories of embodiment, including embodied interaction (Dourish, 2001). Dourish claims that embodiment is the ability to turn action into meaning, and that a key relationship in this process is the relationship between action and representation. Another related research area that can help guide this research is embodied cognition, particularly the idea that the function of cognition is to guide action (Wilson, 2002), and that conceptual understanding itself is grounded in perception and action (Barsalou, 2009). If action does underlie conceptual understanding, this could have important implications for the design of learning environments, and highlights the role that physical objects and associated actions may play in building abstract conceptual understanding from physical experience. In one pilot study for this research project, participants who had used a mixed reality environment to conduct inclined plane experiments were more likely to draw from their physical experience to explain their data than those who used a computer simulation with either a mouse-based or joystick-based input. Building from this pilot study, this project will also explore the role that physical action may play in meaning making with mixed reality learning environments.

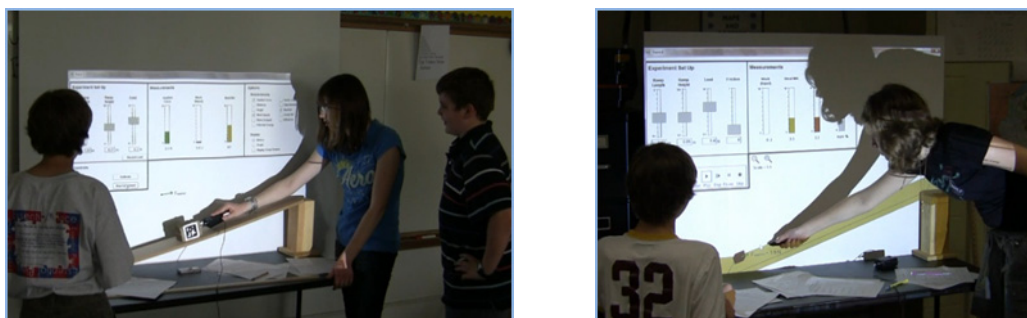
## Methodology

This research is being developed as part of the CoMPASS project, a design-based research program investigating the integration of a digital hypertext environment, hands-on experiments and design challenges within a middle school inquiry science curriculum (Puntambekar, Stylianou & Goldstein, 2007). The following sections describe a mixed reality inclined plane learning environment that I have designed to investigate the research questions above as well as the data sources and analysis methods that will be utilized in this work.

## Design: An Inclined Plane Mixed Reality Learning Environment

Designed to be incorporated into the CoMPASS simple machines curriculum, I have developed a prototype mixed reality learning environment that combines the real-world materials from an inclined plane physical experiment and projects digital representations (e.g. graphs, numeric values, vectors) of formal variables (e.g. force, work, potential energy) onto the surface behind the experiment. The environment also allows students to

explore the same physics phenomenon in a simulation, allowing students to adjust additional variables (e.g. friction, load) that would be impossible or impractical in physical experiments. This environment can potentially allow students to progressively idealize their everyday experience in the real world to the abstract concepts and representations of formal physics.



**Figure 1.** Students using the mixed reality environment to perform physical (left) and virtual (right) experiments.

To be able to track real-world objects and actions, the environment combines several different forms of input. An electronic force sensor is used to track the amount of force applied while pulling the brick up the inclined plane. Fiducial markers are tracked by a webcam, allowing for tracking of the position and orientation of the brick. These inputs are fed to a laptop, and additional variables (e.g. work, distance, height, potential and kinetic energy) are calculated based on these input values. Additionally, an infrared pen is read by a Nintendo Wii remote (Lee, 2008), allowing for students to adjust properties of the environment at the screen without a separate keyboard or mouse interface.

### Data Sources and Analysis

This project will take a mixed methods approach to investigating the research questions outlined above. Separate studies will be conducted to compare this mixed reality learning environment to separate physical and virtual experiments and to examine particular design choices within the environment itself. How students collaborate across the conditions will also be studied, paying particular attention to the role that the representations play in acting as shared referential anchors for joint attention. Each study will consist of an embedded design (Creswell & Plano Clark, 2007), with qualitative data embedded within a quantitative, experimental design. The quantitative component will involve groups of students randomly assigned to an experimental condition, with changes from pre-test to post-test on a physics concept test. The qualitative component will include a multimodal analysis (O'Halloran, 2004) of students' speech, gestures and action during their physics investigations, as well as structured interviews after completing their investigations. The studies will take place within middle school science classrooms as well as with undergraduates in a laboratory setting. This will allow for ecological validity as well as to more closely investigate in a controlled environment the particular factors that influence learning in physical, virtual and mixed reality learning environments.

### Current Status of the Project

Additional pilot testing is currently being conducted with this mixed reality learning environment (both in the classroom and in the laboratory), and the dissertation will be formally proposed in September. The CSSL doctoral consortium workshop will take place before data collection begins in Fall 2011. I believe this timing would make the workshop particularly valuable for the progression of my research.

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## Part 7



# Early career workshops



# Study of the Role of Graphic Representations and Their Interrelation with Written Language in Collaborative Problem Solving

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**Abstract:** The spoken or written dialogue has been de principal source for the analysis of the process of collaboration. The actual computer supported collaborative learning environments offer the opportunity to interact through verbal communication in parallel with tools to create collaborative graphical representation. The process of creation of this kind of representations offers a new source of information to analyze the interaction as a complementary source to dialogues, considering its participation in the communication in addition to its role to represent the joint solution. This study explores the role of the graphical representations in the collaborative solution of a problem in relation to the written dialogue and to the different mechanisms and processes involved.

## Introduction

The work with multiples representations has shown the benefits of complementary semiotic representations and also have been identified the difficulties of learners to coordinate and translate from one representation to the other. The graphical representation considered in this research is created in an editor for simple graphical representation consisting of nodes and links between nodes. The graphical language is defined by a set of elements and valid operations between the elements of the language. The written communication is available through a chat. The graphical representation chosen has simple elements and operations to reduce the load of coordination and translation between written languages and graph (Ainsworth, 1999).

The graphical representation helps to represent the state of the joint solution created and also serves as a support to the process of co-construction of the solution and reaching agreement. In the process of collaborative problem solving, the communication through the written language is intertwined with the communication through the representation and the operations in the graphical representation.

## Goals of the Research

The goal of this research is the analysis of the communicative function of the graphical operations, intertwined with the written dialogue:

- ¿What communicative functions have the operations and sequence of operations on the graph?
- ¿What is the role of the graphical operations (or sequences) in the collaborative mechanisms and processes of problem solving?
- ¿Which is the inter-relation of the communication through the graph and the written dialogue?

## Background of the Project

Interaction analysis research is generally related with verbal interaction, however has been observed that actions of the users also have a communicative dimension that can help to understand the work and learning of the group. Interesting collaborative behavior has been recognized by action-based collaboration analysis using a formal model of activities in a process-oriented monitoring of group interactions (Muhlenbrock, 2001).

Graphical representations serve as medium in which information is accumulated, transformed and interpreted, but research has reported that online collaborators treated a graphical representation as a medium through which collaboration took place and actions in the graph appeared to be an important part of participant's conversations with each other. This has lead to research about how they support the collaborative aspects of knowledge construction (Suthers, 2005).

According to the author, analysis under several theoretical perspectives of the graphical representation and the graphical actions can lead for example to identify indicators of understanding of meaning and acceptance, externalizations that lead to the identification of difference of interpretation, transformations across individuals that can be interpreted as an inter-subjective cognitive process as knowledge construction, ways in which the representation mediates interaction by virtue of its form, its role initiating and capturing the results of negotiations of meaning and supporting conversations. The analysis of the role of the graphical representation is closely related to the different mechanisms and processes of collaboration and the study of them in dialogues.

The theoretical aspects related include the establishment of a shared meaning via the construction and accumulation of a common ground, a body of shared knowledge (Clark & Schaefer, 1989). Meaning can be coordinated and mutual intelligibility achieved because conversant provide constant evidence, positive and negative, that each utterance has been understood, and engage in repairs when it has not (Schegloff, E.A., 1991).

For Roschelle & Teasley (1995) the Joint Problem Space (JPS) is a shared knowledge structure that supports problem solving activity and comprises an emergent, socially negotiated set of knowledge elements such as goals, problem state descriptions and problem solving actions. The students use the structure of the conversation to continually build, monitor and repair the JPS. This includes language, actions and combinations of words and actions. The principal categories considered in the discourse analysis are: structure of turn taking as a measure of mutual understanding and shared problem representation; socially distributed productions for constructing shared knowledge; repairs to solve troubles in comprehension of the dialogue (justifications, counter-suggestions, assertions and elaboration); narration to enable partners to monitor each other's actions and interpretations and actions to present new ideas.

The negotiation, has been modeled (Baker, 1994) based on a set of communicative acts and relations between the offered propositions. Negotiation plays the role of coordinating problem solving and communicative action, establishing mutual understanding with respect to the possible solutions and co-constructing agreed solutions themselves. The negotiation can be at the domain task level or at the communication level. Can be negotiated the goals, knowledge, viewpoints, solutions, methods, perception, understanding, rights image of the other, structuring sequences, topic shifts, management of turn taking etc. The process involves making offers or proposals by one agent and the acceptance or rejection of them by another, in refinement process with the goal of reaching agreement on the proposed solution. The argumentation strategy also can be chained from a negotiation process to solve some conflict, based in the identification of thesis, arguments, opinions and warrants (Baker, 2009). During the strategy of refinement in a negotiation, the knowledge is transformed and elaborated by several operations of contraction, expansion, foundational and neutrals.

To analyze the quality and characteristics of the collaboration, several frameworks and methodologies have been reviewed (Baker, 2002, 2007; Spada, 2005; Detienne, 2008) to identify the possible aspects in the interaction in two cases: through the graph alone and through the graph and the chat. They are considered as references for the analysis but the synthesis of this methods or the creation of a new method are outside the scope of this work.

## Methodology

The analysis is based in qualitative case study. The preliminary interaction data has been obtained from a previous pilot experiment with 8<sup>th</sup> semester students of electronic and mechanical engineering, solving an open problem at distance in dyads (Angeles et al, 2007), working at distance through a chat and a collaborative graphical editor. The pedagogical design of the experiment covered all the steps of the problem solving methodology but the analyzed data correspond to the **generation of alternatives of solution** session, related with the selection of rehabilitation equipment for a patient (see Figure 1). The collaborative tool used for the session was Cool Modes (Pinkwart, 2003).

The methodology of analysis of the interaction includes two principal steps: a detailed micro analysis of the graphical operations and an extension to the analysis of the written dialogue. The objectives of the qualitative micro-analysis are: the definition of the set of graphical operations, its characteristics, communicative function and relation with the knowledge operations. This analysis includes the possible identification of meaningful sequences for the collaboration exclusively found in the sequence of graphical operations. The identification of sequences will be theory and data guided.

The extension of the qualitative analysis to the written dialogue includes the identification of: communicative functions not present at the graphical representation and several meaningful sequences in which both languages are intertwined. This process is related with collaborative mechanisms for problem solving, as negotiation and argumentation for the co-construction of the solutions, the processes of grounding and negotiation of meanings for joint understanding.

To continue the analysis, new data will be obtained in an intervention with a similar design to the previous pilot experiment. From the new data, different cases will be chosen for the qualitative analysis.

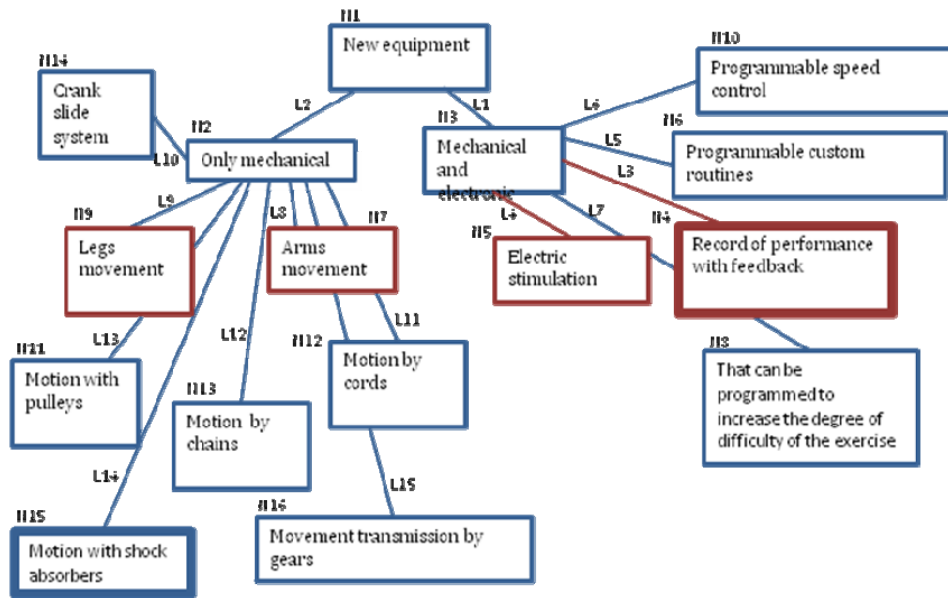


Figure 1. Generation of Alternatives through Chat and Graphic Representation.

**Current Status, Preliminary Results or Results of Pilot Work**

The first preliminary results are based on the interaction data of a pilot study and include a first analysis of the graphical operations, as an attempt to make an interpretation of the multi-dimensionality (Angeles et al., 2007). In this first study, the dimensions include the role, the feedback (implicit, explicit) and the type of the action. In this attempt, the multi-dimensionality of the actions is quantified to define three dimensions of collaboration (Baker, 2002): symmetry, alignment and agreement. The symmetry is defined as change in roles, the alignment as a difference in level of propositions and feedback and the agreement as a difference in positive and negative feedback.

Several inaccuracies have been identified in the previous analysis (see Figure 2). The concept of role needs to be extended to consider a sequence and not only an individual action, consequently the definition of the symmetry dimension needs to be updated. The dimension of alignment needs to be redefined to consider the process of mutual understanding. The process of agreement needs to consider the mechanisms of negotiation. In the preliminary study, have been defined rules to identify acceptance and rejection but they were not integrated as part of the negotiation to reach agreement.

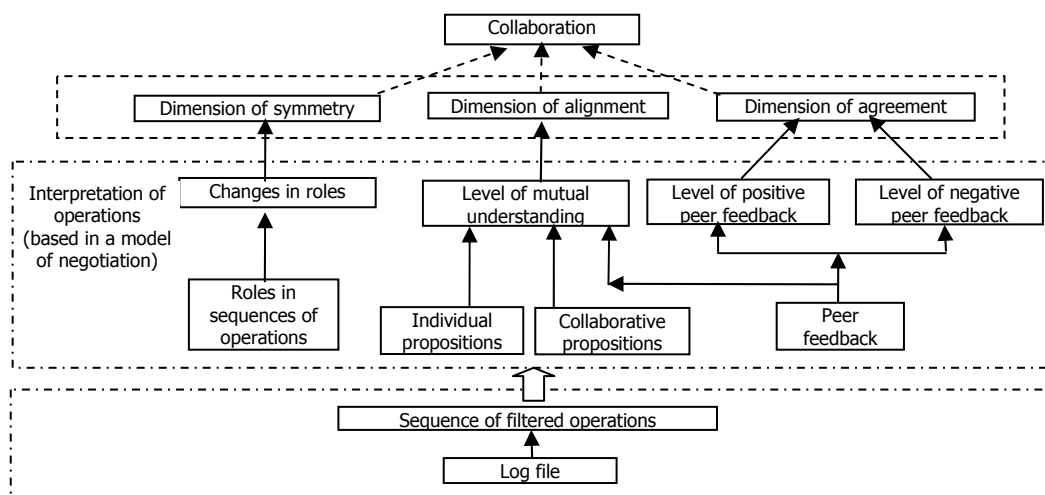


Figure 2. Aspects of the Dimensions of Collaborative Problem Solving for Graphical Representations.

The current status of the research is a process of definition of the space of graphical operations and a detailed analysis of its relation with knowledge construction and its communicative functions in several dimensions. The dimensions considered are: co-construction of the solution (through mechanisms of

negotiation and argumentation to construct the solutions and reach agreement), problem solving regulation and interaction management (Baker, 1994; 2009; Baker et al 2007. The actual definition of the set of operations is shown in Table 1 as part of the work in progress. The status of the research is an analysis of the pilot data using these definitions to identify the additional communicative functions in different dimensions. The next step consist in the identification of sequences of operations with a meaning for the process of collaboration, it includes for example, sequences of proposals to get agreement (negotiation) or sequences of refinement that can help to identify mutual understanding. After that, the analysis will be extended to the written dialogue.

Table 1: Definition of graphical operations.

Graphical Operation	Knowledge operation	Relation	Communicative function(s) (CF)		
Create link	Expansion (Association)	Self	Propose		
Create box near to		Other	Propose	Accept	
Move box near to		Us	Propose		
Delete link	Contraction (Disassociation)	Self	Retract		
Move box		Other	Reject		
Delete box		Us	Retract		
Create box	Expansion	Self	Propose		
Modify box (add content)	Expansion (Elaboration)	Self	Propose		
		Other	Propose	Accept	
		Us	Propose		
Modify box (delete partial content)	Contraction (Elaboration)	Self	Propose	Retract	
		Other	Propose	Partial accept	Partial reject
		Us	Propose	Retract	

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## Part 8



# Post-conference events

## The ISLS Early Career Workshop

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### Summary

The *Early-Career Workshop* is meant as an opportunity for researchers working in CSCL and in the Learning Sciences early in their careers to discuss their own research, to discuss post-doc and early-career challenges with peers and senior mentors and to initiate international networks related to their research topics. There will be online interactions (ca. 5 hours) to prepare for the conference workshop where participants try to identify common interests with respect to research and common challenges with respect to the specific phase in their academic career. During the workshop (1.5 days) itself, participants will present their research and get feedback, talk to different mentors in small groups and discuss possible new international research networks with their peers. In addition, a “meeting with the journal editors” session will be organized. The main contents of the workshop are: research funding opportunities for post-docs and early career researchers; how to develop a research agenda; publishing, where and how much; career development and promotion; how to mentor and supervise graduate students; new research methods; possibilities for building international research networks; international mobility/going abroad—How, how long and where to? The workshop will also have a focus on the specifics of the CSCL community and on the challenges with which this community is confronted (interdisciplinarity, gaps between different methodological approaches). The early career workshop is designed for post-doc and early career researchers with research interests in CSCL and the Learning Sciences, starting with those who have just finalized their doctoral thesis to those having up to 5 years of experience after receiving their doctorate.

Table 1: Early Career Workshop Participants at CSCL 2011 in Hong Kong.

Name	Affiliation	Email
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## CSCL 2011 Post-conference Events in Mainland China

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### Introduction

This series of conference activities to be held in three major cities in China is planned to build on the theme Connecting CSCL Research to Education Policy and Practice of the CSCL 2011 Conference in Hong Kong. It aims to draw on national and global exemplars of synergistic advances in CSCL and learning sciences research and educational policy and practice to explore and discuss the current state and the way forward for education developments in China.

Social, economic, and technological changes have prompted educational reforms in many countries and educational change has become a major focus of educational research. Advances in technology and in CSCL and Learning Sciences research provide tools and insights that help to address many of the educational change goals. However, it is widely recognized that these potential benefits are far from being fully realized. This series of post-conference activities in Mainland China is an attempt to bring 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. The program in each of the three cities addresses one of three related subthemes as detailed below.

### Learning Sciences and Educational Innovation: Policy, Practice and Outcomes—Guangzhou Post-conference July 11-12, 2011

CSCL2011 Post-Conference Activities in Guangzhou will focus on “Learning Sciences and Educational Innovation”. It emphasizes the three keywords: policy, constraints and impact. The activities are designed to engage scholars, teachers, education professionals and administrators in an interactive dialogue on learning sciences and ICT in education. The goal is to foster communication and cooperation in related research in education.

The topics of the Guangzhou Post-conference include:

- ICT and Innovation in Education Policy
- ICT and Education Innovation Methods and Effects
- ICT in elementary and secondary school
- Typical Cases of ICT in Education

Keynote and invited speeches include:

- *Where is Knowledge Building Headed?* By Professor Carl Bereiter, University of Toronto
- *Building Cultural Capacity for Innovation: A Multi-National Design Research Project* by Professor Marlene Scardamalia, University of Toronto
- *Past, present, and future of CSCL* by Dr. Gerry Stahl, Drexel University

Accepted contributions to this post-conference are presented in the form of parallel research roundtable sessions on the following themes:

- Designs and strategies for introducing CSCL in school settings
- Pedagogical considerations and affordances of Technologies for CSCL
- Teacher professional development/ school-university partnership issues

This post-conference is also hosting a Summer Institute on Knowledge Building, which includes workshops and discussions on:

- Getting started with knowledge building
- Embedded, Transformative, and Concurrent Assessment
- Cooperative Research and Data Sharing
- Next-generation Knowledge Building Environment
- Hubs of Innovation: Current and Future
- Case Examples of knowledge building in practice



- International courses and grant getting to support collaborative initiatives: starting the conversation

## **Learning, Curriculum Transformation and Pedagogical Innovation in the Age of Digital Technology—Shanghai Post-conference July 11-12, 2011**

CSCL2011 Post-Conference Activities in Shanghai will focus on studies of learning and educational change. The keywords to be highlighted are digital technology, learning, and curriculum transformation to address the needs of contemporary educational development. The conference activities are designed to initiate multiple dialogues around digital learning among participants from a wide diversity of backgrounds: scholars, educational administrators, educational enterprises, teachers, school administrators, and educational researchers. It is hoped that this post-conference will contribute to building consensus and the construction of new and productive ideas, strategies and methods, so as to make progress in Chinese and International Education in the digital age.

The topics of the Shanghai Post-conference include:

- Learning in the digital age
- Digital technology and curriculum transformation
- Creative practice with digital technology in education

Keynote and invited speeches include:

- *Educating for Innovation from Theory to Practice: The Learning Sciences and Schooling* by Dr Keith Sawyer, Washington University
- *Teacher education in the digital age* by Youqun Ren, East China Normal University
- *Innovational Practice of 1:1e-Learning in Classroom* by Minghe Jiang, East China Normal University
- *21st Century Learning* by Karen Price, Harvard University
- *The creative practice of e-Education* by Jiahou Li, Shanghai Normal University
- *A Dynamic, Complex System Approach to Collaborative Knowledge Building for Sustained Innovation* by Jianwei Zhang, State University of New York (Albany)
- *The Future of English Language Learning* by Pengkai Pan, Saybot Information Technology (Shanghai) Co., Ltd

Accepted contributions to this post-conference are presented in the form of parallel panel discussions on the following themes:

- Web 2.0 tools to support learning
- Games & Learning resources

An important highlight of this post-conference is a number of experiential demonstrations on E-learning supported by high-technology in Shanghai:

- Instruction based on Blackboard
- 1:1e-Learning
- Smart bilingual learning
- Smart class system based on Internet of Things

## **ICT and Educational Transformation: Roles, Factors and Sustainability—Beijing Post-conference July 14-15, 2011**

CSCL2011 Post-Conference Activities in Beijing aims to draw on national and global exemplars of synergistic advances in CSCL and learning sciences research and educational policy and practice to explore and discuss the current state and the way forward for education developments in China. While advances in technology and in CSCL and Learning Sciences research provide tools and insights that help to address many of the educational change goals, it is widely recognized that these potential benefits are far from being fully realized. This post-conference is designed to bring in a strong policy focus and to discuss issues and strategies for national/regional education development that can leverage the promises of learning technologies and learning research on practice. It also marks the final conclusion of the two week long CSCL 2011 conference activities.

Keynote and invited speeches include:

- *Teaching as a design science: Using CSCL for a sustainable approach to pedagogic innovation* by Professor Diana Laurillard, London Knowledge Lab, Institute of Education
- *International developments in information technology and curriculum integration theory: analysis ponderings on the construction of a new integration theory* by Prof. He Kekang, Beijing Normal University
- *CSCL: Past, Present and Future of Research on Educational Technology in the West* by Dr. Gerry Stahl, Drexel University

Accepted contributions to this post-conference are presented in the form of parallel research symposia on the following themes:

- National/regional initiatives to build research capacity on technology-enhanced learning
- National/regional initiatives to build professional capacity of teachers to undertake sustainable pedagogical innovations
- National/regional education reform policies to build human resource capacities for the 21st century, and the role of education research in policy formulation

A highlight of this post-conference events is a visit to an experimental school (High School Affiliated to Renmin University of China, Xishan) for the project “Research on Transformative Development and Innovation in Basic Education”. It provides participants with an experiential understanding of technology-enhanced pedagogical innovations in action in China.

On the last day are two parallel panel discussions that address the overall conference theme, before bringing the conference to a productive closure:

- Connecting CSCL/learning sciences research to educational practice,
- Connecting CSCL/learning sciences research to educational policy.

### Local Organizing Committees for the Post-conferences

	Guangzhou	Shanghai	Beijing
Chairs	<ul style="list-style-type: none"> <li>▪ Fuyin Xu, SCNU</li> <li>▪ Jun Xu, SCNU</li> <li>▪ Hongguang Peng, Guangdong Center of Educational Technology</li> </ul>	<ul style="list-style-type: none"> <li>▪ Zhiting Zhu, ECNU</li> <li>▪ Youqun Ren, ECNU</li> <li>▪ Pengkai Pan, Saybot Information Technology (Shanghai) Co., Ltd.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ronghuai Huang, BNU</li> <li>▪ Shengquan Yu, BNU</li> </ul>
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\* SCNU stands for South China Normal University

ECNU stands for East China Normal University

BNU stands for Beijing Normal University

# ICT in EFL Teaching and Teacher Development: Responding to a National Reform

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**Abstract:** In this paper, I first introduce the background of my study: the national College English Reform in China, in which ICT-integrated language teaching and learning is highly recommended. The reform has brought a big challenge for EFL teachers and called for ICT-related development opportunities. Then I talk about the role that ICT plays in EFL teaching and teacher development. Findings and recommendations for policy-makers are shared with readers as well.

## Introduction

Because of its 'time-wasting and low efficiency', English teaching in Chinese colleges and universities is facing huge challenges and cannot meet the requirements of social and economic development in the 21st century. With the expansion of enrolment in colleges and universities since 1999, pressure was brought on College English teaching and EFL teachers. The Ministry of Education (MOE) then started College English reform in 2002 and set new College English Curriculum Requirements in 2007. According to the Requirements, colleges and universities should remould the existing dominant teacher-centred pattern of language teaching by introducing computer and Web-based teaching models.

The emphasis on the integration of ICT in the reform was in large measure a response to external factors such as fast-rising student numbers and an insufficient supply of qualified teachers in Chinese higher institutions in the past decade. ICT-integrated ELT was regarded as a rational alternative to the traditional approach to teaching.

## The Role of ICT in Language Teaching

Literature has shown the huge advantages that ICT has brought to schools or institutions and to language teaching, but ICT is not 'a panacea'. ICT could not take the place of all traditional tools. The EFL teachers in this study regarded ICT as a supplementary tool when it was used in language teaching. Teachers expressed their ideal use of ICT in the English class as 'getting whatever I want and whenever I need it.' But when ICT facilities were available, some teachers overused them. Such as in multimedia teaching, teachers depended too much on courseware and students spent too much time reading content on the E-screen. This indicates that the high percentage of ICT use does not necessarily mean effective or appropriate use of ICT. Therefore, it seems important for teachers to see what role ICT should play in their classes and how to keep a balance between the use of ICT and traditional tools.

One reason for introducing ICT in this reform was to tackle manpower problems and ICT made it possible to tackle certain manpower problems in education. In my study, ICT allowed the university to cope with more students because teachers' teaching hours had been cut down. However, we should admit that, although ICT can help institutions cope with ever-increasing student numbers, the advantage of ICT in this respect only applies when certain conditions are met, such as provision of sufficient ICT resources, the managed and supported change of teachers' and students' traditional roles, enough ICT competence grasped by teachers and students, efficient technical support and reliable and cost-effective assessment/appraisal systems (O'Mahony, 2003).

## The Role of ICT in Teacher Development

Educational change is a learning experience for all involved in the process. All serious reform efforts are bound to fail if the quality of teachers is not taken into serious consideration (Fullan, 2002). With regard to continuous change in technologies, teachers need adapt themselves to the advance in ICT use in education, trying to adopt it efficiently in their pedagogy. In my study, the majority of EFL teachers had positive attitudes towards the national reform and showed their willingness to use ICT in language teaching. At the same time, they confessed to a lack of ICT-related skills and felt the need to develop their ICT skills to meet the demand of the College English reform. Whereas the willingness and ability of teachers to integrate technology into their teaching is largely dependent on the professional development they receive (Watson, 2001; Hu, 2009).

Although the importance of integrating ICT in education and teacher training/development seems to be increasingly recognised by governments and teacher training institutions throughout the world, research suggests that ICT is still used as the main content focus of teacher training (McCarney, 2004). But with the fast development of technology, increasing emphasis is likely to be placed on learning with/via ICT. As shown in Figure 1, ICT also has a potentially beneficial role to play in language teacher CPD.

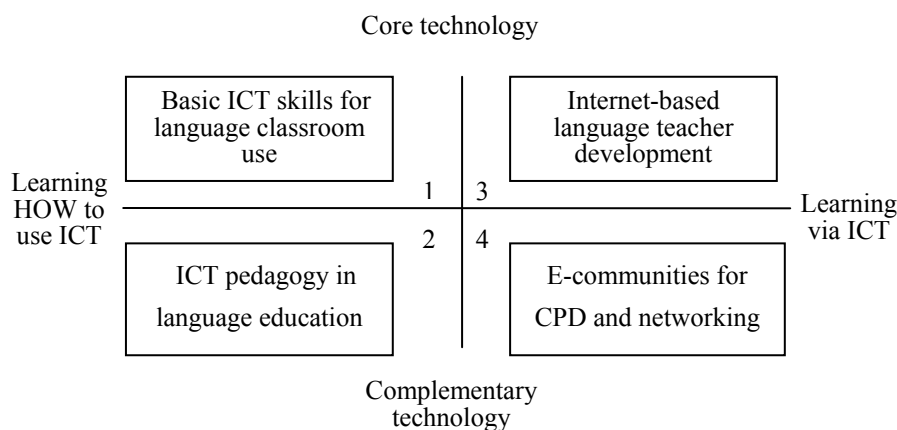


Figure 1. ICT Categories in Language Teacher CPD (adapted from Jung, 2005).

According to Jung (2005), teachers can be trained to learn how to use these new technologies in their teaching (Categories 1 & 2) and they can be trained via ICT (Categories 3 & 4); in other words, ICT can be used as a core (Categories 1 & 3) or complementary focus or delivery method (Categories 2 & 4). In my study, EFL teachers in the university mainly acquired basic ICT skills for language teaching (Category 1); a few teachers were trained in general ICT pedagogy; very few had an understanding of ICT pedagogy in language education (Category 2). As a medium for CPD, ICT was mainly used for EFL teachers' self-directed development; Internet-based CPD training programmes were rarely identified (Category 3). The communication among teachers and collaborative CPD was limited and e-communities for CPD (Category 4) were non-existent.

As discussed above, ICT could be much more fully exploited in language teaching and teacher education; therefore, teacher educators in China or elsewhere should therefore reconsider the means by which they conduct teacher training. For those responsible for coordinating ICT-based CPD, setting up e-communities and networking for teachers to communicate may be an efficient way to promote collaborative CPD.

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## Exploring Ways of Engaging Pre-Service Teachers in Online Collaborative Knowledge Construction

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**Abstract:** This study examines how pre-service teachers learn Internet resources with the support of a Web annotation tool. The collaborative web annotation tool was used to encourage collaborative knowledge construction on Internet resources. With the tool, students were able to post and share comments in adjacent to the particular part of the online text. Student participation is studied in terms of the quality of discussion, students' learning, and their perceptions of learning in the two environments.

### Computer Supported Collaborative Learning

Computer-supported collaborative learning is focused on "how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members" (Lipponen, 2002, p. 72). Grounded in social cognitive theory (Piaget, 1985), social constructivist theory (Vygotsky, 1978) and situated learning theory (Lave & Wenger, 1991), computer supported collaborative learning has a number of benefits to student learning, including promoting critical thinking skills, actively involving students in the learning process, and fostering peer modeling of problem solving techniques (Roberts, 2005).

This paper examines whether and how a Web 2.0 social annotation tool – Diigo ([www.diigo.com](http://www.diigo.com)) supports collaborative learning of Internet resources. With Diigo, learners can make text-based annotations on a webpage by either adding a floating sticky note or highlighting a specific portion of the text and commenting on it. The annotations can be private or shared within a group, where group members can see and respond to each others' annotations.

The research questions are:

- How did students participate in a collaborative Web annotation activity?
- What was the nature of collaborative learning and knowledge construction?
- How did students perceive their learning of Internet resources with the Web annotation tool?
- What are the affordances and constraints of the Web annotation tool in terms of supporting collaborative learning of Internet resources?

### Methods

#### Procedures

Participants were 33 pre-service teachers enrolled in two sections of an undergraduate course on educational technology and volunteered to participate in the study. A week before the implementation of the study, students learned the tool Diigo in class, and practiced how to make collaborative Web annotations on an online article with Diigo. Then the study was conducted in a unit where Google Forms were introduced. Students read an online article for ideas of using Google Forms in K-12 classrooms, and were instructed to use Diigo to make annotations, share annotations with their classmates, and respond to their classmates' annotations. The activity last for one week, and students were required to post at least one independent comment and one reply with Diigo. At the end of the week, students completed a brief survey on their experience of participating in the activity.

#### Measures

All student comments will be tallied to determine participation rates. In addition, a set of coding schemes were used to measure different dimensions of the comments: (a) focus; (b) content; (c) evidence of collaborative learning mechanism; and (d) types of knowledge construction processes.

**Focus.** To determine the focus, each comment will be coded into one of the four categories: (a) general response: responses not closely related to the specific texts, but related to the topics in general; (b) response to a paragraph: responses to ideas in a paragraph; (c) response to a sentence or phrase: responses to a specific sentence or phrase; and (d) irrelevant: responses that are irrelevant to the text.

**Content.** The main purpose of the activity was to have students reflect on many ways of using Google Forms suggested in the article and discuss why and why not they are good ideas, and discuss other possible ways of using Google Forms. To capture student responses to these questions, the following information will be recorded: (a) reasons generated by students regarding why and why not Google Forms should be used in certain ways, and (b) additional ways of using Google Forms proposed by students.

**Collaborative learning.** A coding scheme will be developed based on Dillenbourg and Schneider's

(1995) mechanisms of collaborative learning to identify behaviors of collaborative learning.

Knowledge construction. Pena-Shaff and the colleagues' (2001) coding scheme will be used to identify types of knowledge construction processes taking place in the activity.

Student Perceptions. A brief survey was used to measure student perceptions. It contains a Likert-question and three open-ended questions. The Likert-question asked students to rate the degree to which the collaborative activity helped them learn the online article. Then the open-ended questions asked student to explain why they rated it that way, and what types of discussion/learning behaviors Diigo supported or failed to support.

## Results and Discussions

Students' questionnaire responses provide preliminary data on students' perceptions of the collaborative online activity. For the Likert item, a score ranging -2 to 2 was given based on how students rated the supportiveness of Diigo in helping them learn the article, where -2= not at all, -1= not very well, 0= to some extent, 1=quite a lot, 2= extremely supportive. Table 1 presents the frequency and percentage of student ratings. In general, the majority of students thought Diigo was somewhat (54.5%) or quite (33.3%) supportive. Only one student rated it as not supportive (3%).

Table 1: The frequency and percentage of student ratings on Diigo environment (n=33).

Student Ratings	Frequency	Percentage
-2	0	0.0
-1	1	3.0
0	18	54.5
1	11	33.3
2	3	9.1

The mean of student ratings is 0.48, and standard deviation is 0.71. A one-sample t test shows that the mean is significantly higher than 0 ( $t = 3.91$ ,  $p = .00$ ), suggesting students have a moderate positive attitude towards using Diigo to learn Internet resources.

A richer data set, including the analysis of student online comments will be reported in the conference. The results will provide insights on (a) the relation of design of the online environment and the nature of knowledge construction; (b) the pros and cons of using Web annotation tools to support online knowledge construction; and (c) how to design an online environment that engages pre-service teachers in collaborative knowledge construction.

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## 概念转变视角下的教科书研究

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**摘要:** 本文以概念转变理论为理论框架, 以文本分析、问卷调查为主要研究方法, 对上海高中化学教科书进行研究, 分析其是否包含促进学生概念转变的要素。

**Abstract:** This article used the conceptual change theory as the theoretical frame. And used text analysis and questionnaire as the main research methods to research the chemistry textbook used by Shanghai senior high school about whether it contain the element which can facilitate students' conceptual change.

### 理论基础

#### 概念与概念转变

概念是用以组织知识的基本单位, 是建构人类知识的细胞或基本要素。有关概念本质的经典观点将概念定义为“清晰地并能详细说明一整套必要的与充分的属性的符号”。而学习者的头脑并非空的容器, 在进入课堂前已经有了对世界的理解和自发的概念结构。针对学习者在科学概念学习中产生的问题或观察到的现象, 研究者使用“前概念”、“错误概念”“相异概念”等不同的术语来对原有概念进行区分。错误概念通常是指学习者在先前的正式教学中形成的错误理解。前概念是指源于日常生活经验的那些概念, 也称为日常概念。相异概念不同于错误概念, 学习者所持有的相异概念往往具有一定的理性基础, 学习者是在对周围世界经验的理性认识基础上建构相异概念的。

目前主流的概念转变理论有 Posner 基于认识论的概念转变模型, Chi 基于本体论的概念转变模型, Vosniadou 基于朴素理论的概念转变理论等。不同研究者在各自的研究中对概念转变的含义有着不同的描述, 文献中的术语也各不相同。

#### Posner 经典概念转变模型

Posner (1982)提出的概念转变模型, 认为必须满足四个条件概念转变才会发生, 包括: 1) 学习者必须对当前概念感到不满(dissatisfaction)。在概念转变发生之前, 个体必须遇到足够多的无法用当前概念解决的问题, 从而对当前概念丧失信心。2) 新概念必须是理解力可及的(intelligible)。新概念必须能够支撑日常经验并显示出与日常经验之间的内在关系。3) 新概念必须表现出合理性(plausible)。新概念必须看上去有解决问题的可能性, 并且与个体已有的概念和知识相一致。4) 新概念必须是富有成效的(fruitful)。新概念要有引申并在其他领域应用的可能性。

### 研究方法与研究过程

本论文主要以 Posner 的概念转变四要素, 以及 Roth 的教科书编写原则为理论框架, 以文本分析和问卷调查为主要研究方法, 配合少量非正式访谈, 对教科书进行具体分析, 以了解上海现行的高中化学教科书的编制是否有利于学生的概念转变。

分析对象为上海现行的高一、高二年级化学教科书《高级中学课本·化学》(上海科学技术出版社, 2007)。具体的文本分析对象为高二年级化学教科书第 11 章《认识碳氢化合物的多样性》, 11.1 节《碳氢化合物的宝库——石油》。

问卷调查分为三部分。第一部分工作单包括 3 道主观性开放性问题, 目的是调查学生在学习有机化学之前具有哪些前概念。第二部分学生问卷共 10 道选择题, 为避免模棱两可的回答选项设置使用四分法代替传统的五分法, 部分问题后设有追问。该问卷目的是了解学生对化学教科书的使用情况、理解难易度等, 是对高中化学教科书的整体看法, 不针对具体章节。上海的两所高中接受了这两部分问卷调查, 一所市级实验性示范性高中, 一所普通高中。两所学校共收回问卷 164 张, 其中有效问卷 135 张。参与班级均未系统教授过有机化学部分内容。问卷调查的第三部分是针对教师进行的调查, 选项设置同样采用四分法, 并在每题后设置追问, 目的是了解教师对各问题的详细想法。参与调查的教师共 9 人, 来自上海 5 所不同的高中。

## 数据分析与结论

在对问卷及工作单进行统计与分析后，得到以下结论：

1. 课堂上和课后，学生教科书使用次数都较少
2. 学生的已有概念与教科书内容脱节，教科书需增加内容帮助学生认识到已有概念的不足
3. 教科书概念的难度较为恰当，但应适度增加推导过程，而不是直接呈现结论
4. 教科书的插图与实验探究活动编制较为合理，具有趣味性，同时与需要学习的新概念联系紧密，有利于学生概念转变。
5. 教科书的习题过于浅显，难以准确测试学生的概念掌握程度
6. 教师和学生对教科书的总体评价都是正面的，但教师普遍认为，教科书内容较浅，难以应对目前的考试要求。

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# 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

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**摘要:** 本研究从系统观点出发,通过设计实验研究,发现化学教师学科知识具有层级嵌套的结构,并通过个案分析发现这种结构对教师设计教学方案具有较明显的影响。

**Abstract:** With design based research under a systematic view, we find chemistry teachers' subject matter knowledge has a hierarchy-nested structure. With case analysis, we find this structure with systematic characteristics which perform as complex system will significantly impact on teachers' instruction design.

## 理论基础

### 教师的学科知识对教学实践的影响

舒尔曼曾经指出,教师特有的专业知识——教学法内容知识(PCK)是一类不同于单纯学科知识和一般教学法的特殊知识。PCK的实质是教师可以根据教学情境的需要,将特定的学科知识进行调整,整合,使之转化为适应于教学的形式的一种专业知能。(Schulman, 1987)。

教师理解学科知识的深度和方式都会对其设计教学产生影响。过往研究已有充分证据表明此种影响的运行方式并非单一的线性关系,而是具有复杂的系统特性。

### 教师学科知识的系统特点

B·Davis的研究表明,教师的学科知识具有复杂系统的特征。突出表现为教师的学科知识具有层级嵌套的特征,且层级既存在相互作用的影响,又可以按照一定的序列递进形成复杂的自组织系统。(B.Davis, 2006)

## 实验研究

### 实验设计

研究者设计逼近真实的化学教学设计任务,要求被试根据自身对教学主题的理解,设计和选择学科内容和教学法以实现教学目标。本研究中,研究者确定了化学反应原理与平衡这一主题,要求被试充分运用自身的学科知识和教学经验完成课前备课工作。在此过程中,研究者利用量表、概念地图、以及访谈等多种研究方法了解被试的工作过程,追踪其背后的深度思维。

### 被试

被试共三人,均来自A市B中学。三人都拥有硕士学历和中级职称,教龄均在5-7年之间。B中学是一所享誉全国的国家级重点中学。任教B中学的教师都是同行中比较优秀的。

### 研究过程与数据采集

研究主要分为四个阶段进行。首先研究者向被试说明研究的目的和性质,简单的介绍教学设计任务,并要求被试预填一份问卷。问卷由10道多项选择题构成,主要供研究人员了解被试是否能正确理解与教学主题相关的化学知识。回收问卷后,研究者并不对被试直接作出反馈。在阶段二,研究者向被试提供国家课程标准,作为被试确定教学目标的参考。同时研究者要求被试整理和思考教学中涉及的化学知识点,并利用概念地图的方法使被试的思考显性化。在阶段三,研究者和被试围绕概念地图进行深入的访谈,以了解被试是如何理解和建构的学科知识体系的。最后一个阶段,研究者提供一些常见的教学情景的描述,要求被试选择他们认为最为恰当的处理方式并简要陈述理由。最后和被试一起回顾和总结前阶段的工作,并在此基础上由被试提出一个简单的教学设计方案。

数据通过建立档案袋的方式进行采集,研究者将被试编号,将其回答的问卷,访谈纪要和其它文字稿集中建档存放。

### 数据分析与结论

前测试题共10道,均为化学反应原理和化学平衡的相关问题。三名被试中有两人回答对了7道试题,一人10道试题全部答对。显示被试均具有较好的化学知识基础。

被试在列举知识点的时候都比较习惯于按照课程标准的顺序和叙述方式。从被试的列举的内容来

看，三名被试对课程标准和教科书都非常熟悉，所列举的内容几乎涵盖了他们使用的教科书中的全部相关内容。

但是三名被试制作的概念地图却出人意料的简略。被试并不适应这种工作，他们更习惯用文字的方式来阐述知识之间的关系。被试很少对下位知识进行展开和详细分析，往往是按照教材的顺序将一些主题简单连接起来。例如一名被试就用了“化学反应原理——化学平衡——勒夏特列原理”，这样一个非常简单的示意图来表示相关概念的组织。其他两名被试的回答也类似于此。尽管在问卷调查和访谈中，研究者都可以证实被试其实具有较好的化学知识，对于这些主题的下位概念事实上是了解的，但是被试在研究者的提示和要求之下，仍然坚持只采用这种简单的示意。显然的可以看出，被试并没有主动对学科知识进行层级分析的意识，尽管被试有能力将具体的某一个学科知识转化到教学情景中，但是他们对知识之间的相互联系和组织的教学意义考虑得很少。他们更习惯于按照课程标准和教科书的顺序来建构知识体系。由于被试没有将知识组织成一个内容丰富的有层次的系统，也直接影响了他们对教学设计任务的层级分析。

在指明关键的核心知识的环节，三名被试不约而同地指出化学反应基本原理、勒夏特列原理是教学的核心。然而在仔细谈论这两个主题的时候，三位被试都没有指出这两个原理的实质是什么，也没有说明和这两个重要概念相联结的关键概念和学生必须掌握的下位技能。即使研究者试图让被试通过思考如何围绕核心概念开展教学的问题来提示其考虑知识的联结问题，被试仍然反复强调对同一概念进行反复的记忆和练习是教学的关键。当研究者提示其考虑学生可能面临的问题时，被试一致地忽略了认知过程的路径，而是强调结果，认为学生没有理解，所以应该用加强练习和讲解的办法来促进理解。研究者再次发现，由于缺少对知识层级的深入解析，被试在分析学生理解困难的真正原因时显得非常乏力，没有提出一条除了反复练习以外的途径来促进学习。研究者意识到，尽管被试的学科知识较为丰富和精深，但是由于缺乏系统的组织，使其作用大大受限。由于学科知识不能很好地与教学任务分析相联系，被试的学科知识和教学经验都不能发挥效用，正是因为被试对学科知识逻辑体系的分析不清，直接影响了其对教学方法的设计和选择。

在分析真实教学场景的环节中，被试学科知识的静态框架结构对其系统运行结构的影响有充分体现。一名被试在试测时，在连续三道涉及应用化学平衡常数判断平衡移动的题目上出现误解，在分析真实场景时，当问及他将选择那些内容教授的时候，他非常明确地拒绝了有关平衡常数的内容，在谈及理由时，他则质疑平衡常数解决中学化学问题的实效性。当讨论学生在平衡移动的问题上经常出错时，他认为是因为题型繁多造成了认知困难，并建议多练习、记忆题型可以促进学习。在分析一道用勒夏特列原理解答会产生争议（廖梁，张善培，2009）的问题时，该被试自身出现了迷思概念，并且非常坚定地认为运用勒氏原理可以很清楚的解决问题，而对研究者已经指出的逻辑矛盾视而不见。另一名10道测试题完全正确的被试，则体现出优异学科知识对教学能力的影响。该被试在选择教学内容的时候特别地建议学生扩展关于平衡常数的知识，他指出平衡常数的知识可以帮助学生更深刻地理解平衡移动的问题。与上一位被试相反，该被试明确表达了对繁多题型的质疑。在分析学习困难的原因时，这名被试直接指出了教科书中的内容存在衔接问题，学生的下位基础知识不足，应该补充关键的内容。在分析同一问题时，该被试没有简单应用勒氏原理的结论，指出需要仔细推导一下。研究者发现，化学教师的知识具有内部稳定和自组织的系统特征。教师按照自己的理解组织知识，并且不自觉地捍卫这种组织，即使研究者明确地提问暗示，教师坚持地认为传统中学教材中的勒氏原理在解决问题时具有优越性乃至唯一性。研究表明，教师学科知识系统的组织方式对其设计教学有决定性影响，教师更倾向于按照自己理解和组织学科知识的方式来安排教学内容和选择教学方法。

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## 使用“通过设计学习”的方法促进职前教师 TPACK 水平的提高

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**摘要:** 本研究使用“通过设计学习”的教学方法, 设计了一次职前教师短期课程, 以促进职前教师的 TPACK 水平提升。实验前后测量表的结果显示, 课程取得了一定的效果。

**Abstract:** In order to improve the TPACK of pre-service teachers, we designed a short-course by using “learning by design” approach. Data shows that the course made some effect.

### 问题的提出

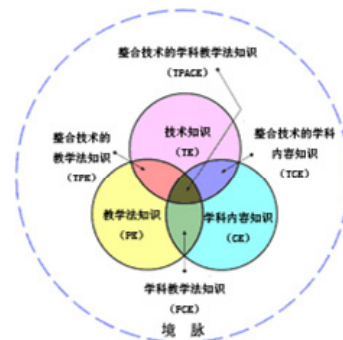
如今, 人们已经认识到教师在课堂教学过程中灵活、有效地使用信息技术的重要性和必要性。传统的教师教育倾向于在学科专业课、教学法课之外设立教育技术课程, 教授具体的信息技术。但这种方式的效果并不理想。怎样有效地帮助教师提升信息技术与教学的整合能力便是本研究主要关注的问题。

### 理论基础

2005 年, 美国密西根州立大学的 Punya Mishra 和 Matthew J. Koehler 首次提出 TPACK (Technological Pedagogical Content Knowledge) 的概念 (Koehler & Mishra, 2005), 并与 2006 年撰文详细阐述其内涵 (Mishra & Koehler, 2006)。他们认为, TPACK 是教师有效使用技术进行教学所必须的知识, 由技术知识 (T)、教学法知识 (P)、学科内容知识 (C) 三者交叉而成 (参见图像 1)。在教师进行有效的信息技术整合时, 技术、学科内容、教学法三者互相影响, 呈现出动态平衡的状态。

TPACK 的提出受到了国外广大研究者的兴趣和热情。一方面, 研究者们开发出各种工具, 用于检测教师的 TPACK (Mishra & Koehler, 2005; Schmidt et al., 2009a, 2009b; Shin et al., 2009; Archambault & Crippen, 2009; Graham & Burgoyne, 2009)。另一方面, 研究们对采用“设计学习”的方法培养教师的 TPACK 达成了一定的共识 (Koehler & Mishra, 2005; Voogt et al., 2010)。更有研究者就如何支持教师的设计过程展开了研究 (Karamarski & Michalksy, 2009, 2010; Trautmann & MaKinster, 2010)。

基于以上国外研究基础及成果, 本研究着眼于国内师范生教育阶段, 聚焦于数学学科, 旨在探究如何提升职前数学教师的 TPACK 水平。



图像 1. TPACK 框架 (图片来自维基百科)。

### 研究方法

本研究采用单组前后测的实验方法, 采用问卷收集数据。结合定性和定量两种方法, 对数据进行分析。

本研究结合了 Schmidt 等人、Archambault 和 Crippen 开发的两份量表, 编写了由 32 道 5 级评估细目组成的量表。经过试测和调整, 这一量表形成了在前后测中使用的两份问卷的核心内容。除量表部分外, 出于为实验结果提供多方面的解释信息的目的, 两份问卷中还包含了其他一些题目。

本研究借鉴了 Koehler 和 Mishra、Kolodner 关于“设计学习”的研究 (Koehler & Mishra, 2005a; Kolodner, 2002), 设计了“设计学习”微型课程教学实验。在该实验中, 被试被要求分小组设计某数学主题的教学方案, 该教学方案必须体现出信息技术与学科教学的整合。微型课程分学习者分析、学习内容分析、教与学活动分析、课件制作、课件与教学方案完善、最终陈述 6 次课, 每次课 150 分钟。为提升微型课程的实施效果, 教师在前四次课上给出了一系列引导型问题, 安排了 1 至 2 轮的“组内讨论—组间交流”活动, 并提供了参考资料, 以促进被试积极思考 T、P、C 之间的关系。

## 数据收集及分析

上海市某高校的 20 名（男性 4 名、女性 16 名）数学专业（大学三年级）的师范生学生参加了实验，共计 13 名（男性 2 名、女性 11 名）被试完成了前后测两份问卷。本研究对两份问卷的量表部分进行了编码和算分，并采用配对 T 检验的方法，得出实验前后这 14 名被试的 TPACK 水平的变化如表格 1 所示。

表格 1: 13 名被试实验前后 TPACK 水平变化。

	pre- Mean	post- Mean	Sig. (2-tailed)
T	3.36	3.49	.709
P	3.39	3.74	.084
C	3.53	3.67	.321
TP	3.52	3.83	.011
TC	3.46	3.82	.024
PC	3.45	3.89	.016
TPC	3.48	3.92	.034

在实验过程中，研究人员记录了所有小组在组间交流环节的发言内容，同时跟踪记录了一个小组在 4 次课中的组内讨论环节中的全部话语。后续研究将参照 Koehler 和 Mishra 的研究 (Koehler & Mishra, 2005b)，对这些话语进行编码和分析，以解释被试在整个教学设计、交流过程中所关注的问题及变化。

## 结论

根据表格 1 所示，在实验前后 13 名被试在 TPACK 七个元素上的平均得分均有所提升。其中，TP、TC、PC、TPC 四个元素的水平变化较为显著 (Sig.<0.05)，而 T、P、C 三个元素的水平变化则不显著。这说明，微型课程在促进被试深入思考 T、P、C 三者的关系方面有一定效果。另一方面微型课程未对 T、P、C 三方面的内容做详细的阐述和讨论，因此被试并未在这三方面做太多的思考与讨论，这是今后的研究需要关注的地方。此外，后期的研究将主要对被试在课堂上的话语进行编码和分析，以得出更进一步细化的研究结论。

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## 科学争议性话题教学对学生反思判断能力的影响

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**摘要:** 本研究以反思判断模型为评价工具, 探讨科学争议性话题教学对学生反思判断能力发展的影响。

**Abstract:** The purpose of this investigation was to explore how the instruction of scientific controversial issues would influence students' development of reflective judgment by using the Reflective Judgment Model as an assessment tool

### 问题提出

随着当今社会越来越多的科学争议性话题 (Scientific Controversial Issues, SCI) 充斥现代人的生活, 培养学生认识、理解争议性话题, 并积极做出有根据的决策, 已经成为新课程改革的重要目标之一 (Agnès Cavet, 2007)。反思判断 (Reflective Judgment) 能力反映学生认知水平的发展并影响学生的推理能力、评判性思维能力 (King, 1994)。科学争议性话题教学对学生反思判断能力的影响是本研究所关注的重点。

### 理论基础

科学争议性话题是指与科学相关的主题, 由于人们的价值观念和利益的不同, 在社会中引起争议的话题, 如克隆人、转基因食品、核能源等 (Dearden, 1981 & Pederson, 1992)。Stenhouse (1970) 在《英国人类课程计划》第一次提出“争议性话题是关于不同个人和组织在行动过程中产生强烈冲突的问题”, 要求将争议性话题纳入学校课程中。之后, 科学争议性话题教学越来越受到教育界重视。科学争议性话题体现问题的情境性和复杂性, 适合采用辩论、小组讨论、角色扮演等教学方式, 有助于激发学生动机 (Samuel, 2000), 培养学生的问题解决能力和决策能力 (Stranding, 1985), 提高学生对科学本质的理解 (Dean, 2007)。Nicholls (1992) 等研究表明, 相比于低年级的学生, 高年级学生更加倾向于合作探究争议性话题, 并且能从中获得问题解决能力的提高。

在目前的教育系统中, 教师仍然是教学的主导。教师对科学争议性话题教学的态度和社会责任意识, 直接影响到教学的实施和有效性 (Standing, 1985; Roger, 1996;), 从而影响学生相关能力的提高。反思判断能力是描述个体认知能力发展的重要因素, 经大量的实验检测, 反思判断能力模型具有较高的稳定性, 已发展成一项重要评价工具, 研究学生的能力发展和教育成就 (Dana, 2009)。本研究以教师对科学争议性话题教学的社会责任意识强弱为依据, 筛选接受科学争议性话题教学最多和最少的学生, 以反思判断模型为评价工具, 揭示科学争议性话题对学生反思判断能力的影响。

### 研究方法

本研究采用设计型教学实验法, 通过调查问卷和访谈法来搜集数据, 以定量和定性的研究方法分析数据。

#### 1. 被试的选择

本研究以 Roger 和 Ronald (1996) 开发的访谈提纲为基础, 对某中学高一年级 6 位化学教师, 分别进行问卷测试和访谈, 通过对科学争议性话题教学的态度、认识水平、经常使用的教学方式和使用频率等 4 个维度进行调查, 请 3 位专家独立为每位化学教师在各个维度上打分, 按照总分排序, 挑选其中表现水平最高 (H) 和表现水平最差 (L) 的两位老师。以这两位老师所任教班级为样本, 随机各抽取 10 名学生作为被试 (H 组和 L 组)。

#### 2. 数据搜集

King & Kitchener (2004) 根据 20 年横向和纵向研究设计出反思判断模型 (RJM), 本研究按照反思判断访谈 (RJI; King & Kitchener, 1994, 2002, 2004) 框架, 分别对 H 组和 L 组学生 (共 20 名) 进行测试, 以此获知科学争议性话题教学对学生反思判断能力的影响。每位学生的访谈都是分别在独立的办公室进行, 访谈者首先向被试呈现科学争议性话题相关的情境描述, 在被试了解该话题相关的主要内容之后, 访谈者提出 7 个常规问题, 鼓励被试呈现自己的立场并对此做出有根据的解释, 然后通过访谈被试对争议性话题相关知识的确信性, 对“专家”观点的认可度等方面的认知观点。PRJ 所涉及的情境包括食品添加剂、酸雨等科学争议性话题。在过去大量的研究显示 PRJ 具有较高的信度和效度。

访谈全程通过摄像机和录音笔记录被试的回答, 并逐字转录成文本, 对访谈结果进行编码。按照反思判断模型所提供的评价标准, 请 3 位熟悉 RJI 量表的专家对各被试反思判断能力做出评价。首先给

每位专家一份从 Zeidler (2009) 关于学生反思判断能力研究中整理出来的访谈记录, 请 3 为评估专家进行独立打分并做出相应解释, 然后对他们的评估结果与 Zeidler 研究的实验结果进行比较, 选择评估结果最相近的专家独立完成所有被试学生反思判断能力的评估。

## 数据分析

反思判断访谈 (RII) 为研究学生理解和评价知识的认知信念提供了可靠的评价工具, 量化评价学生的反思判断能力。根据被试在访谈中所表现出的反思判断能力水平, 在 H 组和 L 组组内进行差异性分析, 并对 H 组和 L 组组间的施测结果进行比较, 找出其差异性和相关性, 并分析其中的原因。

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## Giving Parents Feedback on Individual Children's Progress During On-line Educational Games: [www.kizz.tv](http://www.kizz.tv)

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**Abstract:** CogniK has specific profiling and recommending technologies allowing us to propose content adapted to users' preferences and cognitive competencies. We illustrate how feedback on children's progress during Kizz TV educational games is given to parents. Major publishers (e.g. Scholastic, Lagardère Active, Avanquest) provide us with content we analyze and match with individual cognitive profiles. Collaborations exist with distribution partners in Denmark, Norway, Germany, Sweden and Poland. Discussions are in progress with Chinese partners in Shanghai and Beijing.

### Introduction

Cognitive Tutors (Anderson et al., 1995) are computerized Intelligent Tutoring Systems (ITS) constructed around cognitive models of knowledge, and are founded on an interdisciplinary approach combining models from cognitive psychology with artificial intelligence techniques. According to Koedinger and Corbett (2006), these models represent learner thinking in the target domain as well as the strategies and misconceptions that are typically part of a learner's repertoire as he or she progresses towards expertise. Cognitive Tutor designers argue that students acquire the knowledge encapsulated in the model when solving problems or performing other learning tasks (e.g. learning language) and help them to do so by designing Cognitive Tutors to accomplish two of the principal tasks characteristic of human tutoring: 1) monitoring the students performance to provide context-specific just-in-time instructions and 2) monitoring the students' learning and selecting problem-solving activities that are just within the individual student's reach (Koedinger and Corbett, op. cit). Although research in Intelligent Tutoring Systems has existed for decades (e.g. Psozka & Muller, 1988), it is rare to find successful commercial applications of such technology. A notable example is the Cognitive Tutor for algebra (1), part of a course for high school algebra. In 2004-2005, it was in use in some 2000 schools across the United States.

In this article we propose a newly commercialized educational web service (or web application) called Kizz TV (2) from the company CogniK (3) that is quite similar to the definition of the Cognitive Tutor given by Koedinger and Corbett (op. cit), but due to our particular context, not all of their definition is relevant for us. For example, although we monitor children's progress in order to build each child's cognitive profile, we do not intervene *during* their play; children may either finish a particular educational game or interrupt it themselves (this latter action is taken as an indicator of negative preference and is incorporated into the cognitive profiles we build for each individual learner). Because we do not attempt to intervene *during* children's play, our cognitive model does not contain a representation of children's strategies and misconceptions as could be perceived in their trajectory from novice to expert. Indeed, we have not found it necessary to intervene at that level in order to demonstrate children's progress. Instead, we analyze the educational games the publishers provide in terms of the cognitive competencies that are mobilized during each of the learning activities and gradually build the learner's cognitive profile according to the games he or she succeeds or fails at and likes or dislikes. As the learner plays more games, his or her cognitive profile becomes more precise and the games that the Kizz TV website proposes become more and more adapted to the learner's current level.

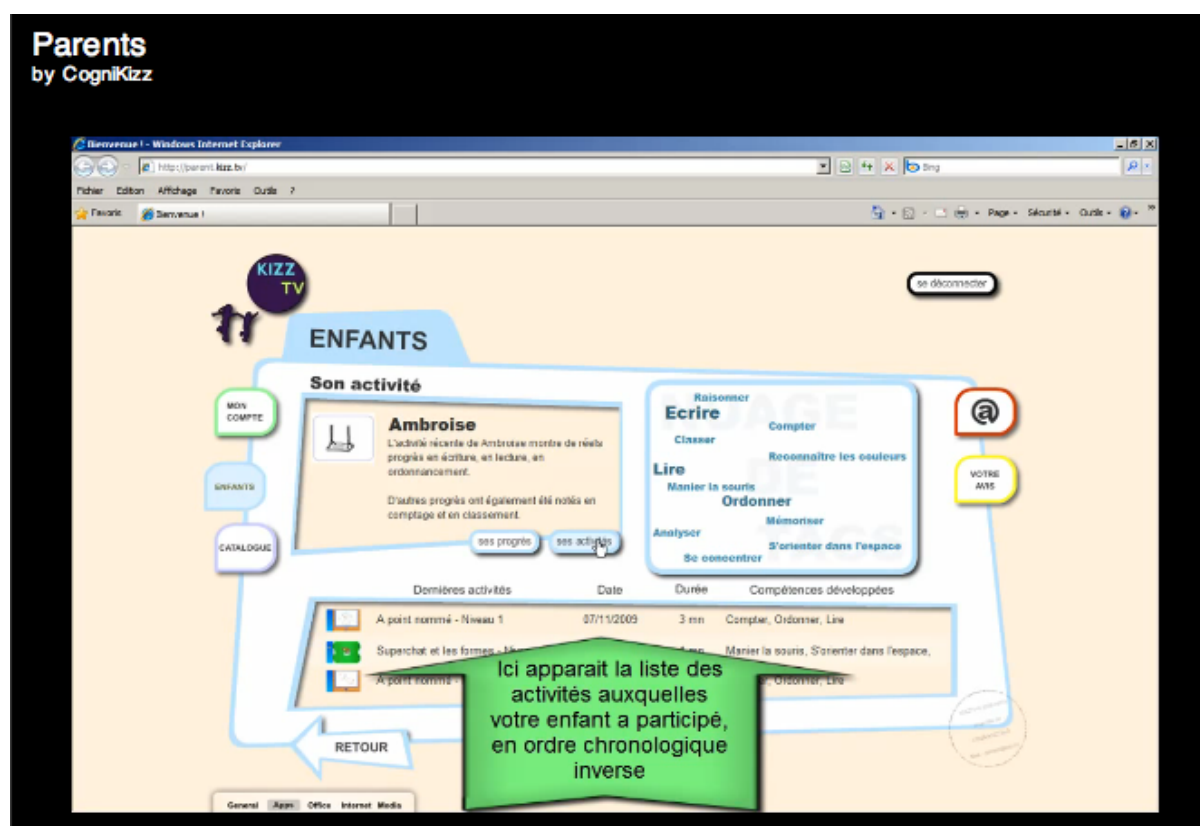
In what follows we will briefly describe our profiling approach and then focus on how we provide feedback to parents as their child progresses through the Kizz TV educational on-line game site.

### Monitoring Students' Performance and Learning and Building Profiles

The Kizz TV system uses explicit profiling (the action of explicitly providing information used in the profile) through a deliberately short questionnaire: birthdate and gender. Although the CogniK profiling method can handle a much wider variety of explicit profiling questionnaires (like/dislike, cognitive development questionnaire, etc...), we mostly rely on implicit profiling for the Kizz TV website. During implicit profiling, learners are "observed" and data gathered. Information on how an educational game is played (number of errors, speed of action, etc.) is as important to know as whether the game was successfully completed.

Profiles need to be matched with content. Hence content must be described in terms which can be used by our recommendation engine. CogniK has built expertise and know-how in the cognitive characterization of content for children. We have methods and tools to scan content and enrich metadata with the learning elements available in educational games.

Figure 1. shows part of our online parent interface (in French) and the caption describes each section of the screen. In general the parent interface allows parents to choose how much time their child spends in the Kizz TV application per week, but also to regulate the amount of time the child spends during one particular session (the default values are those recommended by pedagogical experts). In addition, parents can directly regulate the difficulty level of the educational games their child will play.



**Figure 1.** The upper left part of the parent interface shows a summary statement concerning the child's progress. The top left shows the different cognitive competencies used to categorize the educational games. A bigger font indicates competencies the child is progressing in. The bottom middle of the screen shows the list of activities the child participated in reverse chronological order.

Clicking on an element in the list at the bottom middle of the screen gives a more detailed description of the competence(s) that are mobilized by children while playing that particular game. Parents can also obtain a detailed report concerning their child's progress on 12 different key competencies.

CogniK has established a strong partnership with ICAR, a leading research lab in language and cognitive sciences. This cooperation has led to several iterations in the development of our proprietary artificial intelligence engine, validated by testing in controlled environments. CogniK and ICAR have contributed to pioneering the introduction of profiling and recommendation technologies based on cognitive characteristics into the consumer field.

## Endnotes

- (1) <http://www.carnegielearning.com/>
- (2) <http://www.kizz.tv>
- (3) <http://www.cognik.net>

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## The Inspiration of the Studies of Learning Science in the West for the Studies of Educational Technology in China

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**Abstract:** This paper first reviewed the features of the learning sciences in the West and the issues of educational technology in China. Then, it advised things that educational technology researchers in China can learn from the learning sciences in the West, such as collaborate with other disciplines, focus on the study of learning process, use design-based research method, and ground research in learning theories, empirical data, and rigorous methods.

### The Features of Learning Sciences in the West

Learning sciences (LS) emerged in response to the challenges that research in cognitive science and AI in Education has ignored the complexity of real-world learning that occurs in people's interactions with physical world and with each other (Kolodner, 2004; Sawyer, 2006). LS has some important features that distinguish itself from other fields in educational research (Confrey, 2006; Hoadley, 2004; Kolodner, 2004; Sawyer, 2006):

- LS is a multiple inter-disciplinary research grounded in cognitive science. Learning scientists have various background, such as cognitive science, computer science, education, educational psychology, design studies, anthropology, sociology, instructional design, and others; and they collaborate with each other.
- LS studies learning processes and instructional techniques. Its goal is to identify the cognitive and social processes that result in the most effective learning and the environmental factors that affect how people learn, and use this knowledge to redesign learning environments to promote deep and lasting learning of complex content, skills, and practices. It emphasizes the formation and exploration of theories that explain human learning happened in real world.
- Design-based research (DBR) is the “gold standard” method of LS. It is a new hybrid methodology for studying how students learn in real-world context by letting students work on carefully designed, sequenced learning tasks and analyzing the trajectory of students' learning and their interactions with others. Interaction analysis is often used to unfold the relations among learners, their interaction patterns and problem solving practices, and the trajectory of the interaction and practices.
- Using computer technology is prevalent in LS. Computer technology plays an important role in LS. LS uses the knowledge about human learning and takes the advantages of computer technology in the design of effective learning environment that supported with computer. Computer is used as an important tool toward the advancement of our understanding of learning.

### The Learning Science and Educational Technology in China

The meaning of “Learning Sciences” in China differs from that in the West in its research purpose, the research focus, the theoretical stands, the research methods, and the background of research community members (Jia, 2008). Student learning processes is not the focus of the “Learning Science” in China; computer technology is never used in its inquiry; and DBR is never used in their studies. The “Learning Science” in China has nothing to do with the application of computer technology in education. In China, Educational Technology (EdTech) is the only active field that studies the applications of computer technology in learning.

However, the focus of EdTech in China is the applications of educational media, e.g. computer (Nan, 2009). The background of researchers is simplex. Most researchers have background in electronic engineering and computer science; some of them in education and educational psychology. Many young researchers in this field have degrees in EdTech only; and thus lack first-hand teaching experiences in subject areas.

Researchers in China are keen on arguing fundamental concepts, debating philosophical foundations, constructing disciplinary frameworks, developing technological system and software, exploring the applications of new technologies, and creating theoretical models of applications through purely theoretical, intellectual debate. Few empirical studies have been reported in journals published in China; research methods are not reported in most published articles; studies are not properly grounded in educational and psychological theories (N. Zhao, 2011; Y. Zhao, 2008; Lei & Zhang, 2010). Design-based research is just recognized by researchers in China but often confused with other methods.

### Inspirations to the Research in Educational Technology in China

Compare to other disciplines in China, EdTech has closer research interests to the LS in the West. Thus, in this section we discuss what researchers in EdTech in China can learn from the studies in LS in the West.

- Stress the collaboration among multiple disciplines. There is no communication or collaboration between EduTech and other areas in Education China; needless to say other disciplines. Some researchers admit that EdTech belongs to Education (He, 2005; Nan, 2009); however, it is strange that some of these researchers also suggest EdTech to be independent from the discipline of Education at the same time (Nan, 2009). Multi-disciplinary collaboration can open the minds and views of EdTech researchers in China.

- Focus on the study of students' learning process. Researchers in cognitive science and AI in China have no interests in education; also, researchers in the "Learning Science" in China have limited academic background. Hence, there is no hope for them to pay attention to or to research real world learning in near future. EdTech is the only field that may contribute to the development of indigenous learning theory in the context of China. EdTech researchers are now in an advantageous position to turn their attention to LS. However, EdTech research in China has paid much attention on teacher's instruction but ignored students' learning. Here, we would suggest Chinese researchers to pay more attention to students' learning rather than teachers' instruction for three reasons: 1) constructivist theory stresses that learners must actively engaged in learning activities to construct their own knowledge and learning motivation is very important (Mayer, 2004; Palincsar, 1998); 2) "students cannot learn deeper conceptual understanding simply from teachers instructing them better" (Sawyer, 2006b, p. 2); 3) China has a tradition of focusing on teachers' instruction but ignoring students' engagement in learning; teachers in China has a strong authority image and students have few opportunities to express their own ideas in classrooms; lecture-based, "spoon-feeding" instruction still dominate most of the classes in China.

- Use DBR methodology in studies. China needs more empirical studies in EdTech. DBR is empirical inborn because it takes place in naturalistic context and requires researchers to collaborate with teachers to design and implement instructions in classrooms (Barab, 2006). DBR is effective in dealing with real world learning context. Thus, DBR can help researchers in China develop theories of EdTech that are grounded on empirical data, rather than on purely theoretical, intellectual arguments. DBR requires rigours and justified methods of data collection and data analysis. Simply reporting research outcome is not enough in DBR. Thus, DBR will help Chinese researchers to report their research methods with precision and rich accounts so that others can assess the contribution and connect to their own contexts of innovation (Barab, 2006).

- EdTech researcher in China should ground their research in cognitive psychology and learning theories at the very beginning of a study to guide the generation of research questions, the choice of research methods, and the making of conclusions. They need to think and discuss how their studies have improved or confirmed existing theories and led to new theories of learning as well as how their study has disapproved previous theories or studies. They need to use standardized citation format which will help readers of their research easily locate the original resources and show the researcher's respects to others' intellectual properties.

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# How the Creation of Open Educational Resources Can Impact the Creators: Improving the Quality of Undergraduate Teaching in China

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**Abstract:** China's Top Level Courses Project was initiated by the Ministry of Education in 2003, and has produced more than 12,000 courses. The purpose is to improve the quality of undergraduate education. In this qualitative study, five professors who participated in this project and two administrators from two Chinese universities were interviewed about the process of applying. The main finding of the paper is that the application process itself had an effect on their teaching practice.

## Introduction

At around the same time that MIT OpenCourseWare (OCW) and other OCW projects began the trend of developing Open Educational Resources (OER) organized as entire courses in 2003, China developed a large-scale project for sharing educational resources within its domestic higher education sector, called the Top Level Quality Project (jingpin kecheng, 精品课程) (MIT, 2008). This project, funded by the Ministry of Education, uses the production of Open Educational Resources to improve the quality of undergraduate education. Divided into university-level, provincial-level and national-level, the program has produced more than 12,000 open courses involving more than 700 universities. The Chinese project is unique, not only because of its highly centralized organization and funding, but also because its purpose is not just to produce open resources, but to use the production of open resources to drive curriculum reform in Chinese higher education.

Despite the scale of the project, very little is known about it outside of China. In Han and Liu's (2010) introduction to the project, they cite the five "first-class" criteria for the selection of top courses: "the first-rate teacher teams, learning contents, instructional methods, teaching materials and teaching management". According to Tang (2004, cited in Han & Liu, 2010), the project had three main aims:

- to encourage full professors to teach high-enrolment undergraduate courses with high quality;
- to promote information technology to be integrated into course teaching and learning and reform the instructional methods; and
- to make educational resources freely available to the public (p. 1).

This research project used a qualitative approach to begin to understand how this project is experienced by teachers whose courses are selected as Top Level Courses, and administrators at universities that participate in the project. Interviews were conducted at two universities. University A is a top-ranking national comprehensive research-intensive university in a major city. University B is a provincial level normal university in a different part of the country. At both universities, I interviewed the person in the academic affairs office responsible for coordinating their Top-Level Courses production (A0, B0), as well as several professors (A1, A2, B1, B2, B3).

## Findings

In this paper, I will focus on three themes that emerged from the interviews: how the professors made the decision to apply, and how they felt that the project had impacted them. I also asked academic affairs officers at the two universities how the project had affected the entire universities.

### The Decision to Apply

Both Professor B1 and Professor A2 were relatively early in applying for the Top Level Course designation. In both cases, they realized that their existing material was a very good fit for this new program. Professor A2's school began applying for courses in 2004, and when they asked who had courses that could fit, he volunteered, because he knew that the existing resources they had developed would be very appropriate for the Top Level Course requirements. He also believed it would be an honor to receive the designation.

Professor B1's story is similar, she applied for the campus level designation in 2005, and in 2008 her team applied for the national level designation. She says that they never applied for the designation "excellent course" because they wanted the badge, but because they thought that through the process of applying, they could provide a better course for the students.

Professor B2 also applied for the designation in 2005, but Professor A1 did not apply until 2008, five years after the Top Level Courses project had been launched. She said she knew about it the whole time, but thought that as long as others knew he had a good course, that would be sufficient, and did not consider applying for this designation. In 2008, her department began to put more focus on developing Top Level courses, as part of a process of becoming an international first class university, and expand its influence. At that point, she decided to submit his own course for consideration.

### Effects of Applying on Individual Professors

When asked about what had changed after applying for the Top Level Courses designation, most of the answers from professors centred around the process of applying; while some believed that it had led to a significant improvement in quality, others believed that it had not changed very much. Professor B2 was in the first category, saying that these last years they have been continually improving the teaching materials, largely thanks to the impetus given by the Top Level Courses project.

Professor A2 had always taught his course alone, but because one of the criteria for applying to the Top Level Courses project was the formation of a teaching team, he now shares the responsibility with four other teachers, both training young teachers to one day take over, and involving more senior professors, who would otherwise not engage in undergraduate teaching.

Professor B1's class had always had a teaching team, but she also felt that the project had had a large impact. Her biggest outcome was becoming more aware of the process of course construction, and the goal of course development. Earlier, she believes she did things more randomly and intuitively, without considering why she made certain choices. The process of applying has changed this, now she is improving the class in a systematic fashion, according to guidelines. She believes this has also had an effect on the development of other courses with which the course team members are involved. This statement is echoed by Professor B2, who cited a stronger commitment to reflection and innovation, and closer collaboration with colleagues, as outcomes of the application process.

### Effects on Institutions

There was agreement among the academic affairs officers of the two universities that the Top Level Courses Project had raised the quality of courses, and the awareness of pedagogy and standards. Mr. B0 said that all academic staff who teach now know the national standards for each course, and that this standardized pedagogy has improved the quality of teaching. This goes together with the general increased focus on quality in teaching. However, standardization does not mean a lack of innovation, indeed according to Mr. B0, teachers that earlier taught in a very traditional fashion, with very little discussion in class, had through the process of applying to the provincial Top-Level Courses Project changed their pedagogical ideas, and the design of the class. This is consistent with what Wang (2008) reported from his case study of Lanzhou City College.

Due to the process of applying for Top-Level Courses, professors have also become more tech savvy, and are implementing more educational technology in all their courses. Lectures are recorded, so students who did not catch everything, can watch them again after class. Courses have blogs, where teachers can leave homework, and students can communicate with teachers outside of class.

### Conclusion

In this paper I have discussed how a small number of individual professors and academic affairs officials experienced their participation in the Top Level Courses Project. While the study was limited to only a few professors and universities, and was purely based on self-reported experiences, it should be seen as a first look at a large Open Educational Resources project with a unique approach, using Open Educational Resources to promote the quality of undergraduate education. The findings suggest that more attention should be paid to the process of selecting and developing Open Educational Resources, whereas so far most of the research has been on the use of the resources after they have been made available. There is also a need for more rigorous studies around these self-reported advantages of the Chinese project.

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## ICT and Educational Transformation: Factors towards a Complex Systems Approach to Personalized Learning Communities

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**Abstract:** Information and communication technologies (ICT) has advanced one of the most important visions of educational reformers, to customize formal and informal learning to individuals. And, by its very nature, ICT 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 nine, 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 (Martinez 2001; Shen, Yang et al. 2006; Dede and Barab 2009). 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 et al. 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 information and communication technologies (ICT) have given rise to computer-supported collaborative learning, designs and affordances for more individualized educational experience have flourished even in contexts that are organized around group activity (Fischer and Scharff 1998; Stahl, Koschmann et al. 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 (Wilensky and Shapiro 2003; e.g., Barab and Dede 2007) 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 suggests 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. Hamilton and Jago (2010) describe an earlier version of these primitives 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 can in some fashion activate one another (Hamilton and 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 Table 1 will increase and 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.

Table 1: Ten design emphases from which personalized learning communities emerge (Hamilton & Jago, 2010).

<p><b>Modeling:</b> Emphasis on <b>models</b> or systems thinking and ways to represent connections between ideas. The relationships or operations between ideas becomes as salient as ideas.</p> <p><b>Elicitation:</b> Emphasis on students expressing and representing the conceptual systems, intuitions and tacit understandings <b>they already possess</b>. "Draw out of the student" instead of "put into the student."</p> <p><b>Consequentiality:</b> Emphasis on <b>feedback loops and personal meaningfulness</b> in problem-solving, classroom, virtual world or other settings that are both meaningful to students and that are responsive to them.</p> <p><b>Adaptivity:</b> Emphasis on iterative <b>revisions</b> in feedback or consequence-rich settings. Assessment regards improvement and revision <b>processes</b> as important as knowledge <b>snapshots</b>.</p> <p><b>Personalization:</b> Emphasis on matching high-feedback curriculum experience to individual achievement levels and learning styles. Includes emulating one-to-one <b>personalized tutorial and mentoring</b> experience.</p>	<p><b>Connectedness:</b> Emphasis on <b>socialization</b> in learning, including rich, multilayered connections between individuals.</p> <p><b>Self-regulation:</b> 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.</p> <p><b>Hybrids:</b> Emphasis on diversity of learning modalities and fluid transitions between them, such as between individual reflection and group immersion, between virtual worlds and real context; interoperability of individual-social-machine knowledge forms, and heterogeneous competencies functioning together.</p> <p><b>Creativity:</b> Emphasis on creativity or generativity and connections between ideas in problem-solving.</p> <p><b>Interactional bandwidth:</b> Emphasis on diverse means to express content and meaningful human interaction in the learning environment, especially including new sightlines everyone in a classroom.</p>
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