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NSF 06-609 **01/29/07**

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TITLE OF PROPOSED PROJECT **Collaborative Research: Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **450,999**	**36** months	**08/01/07**	

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REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **299,691**	**36** months	**08/01/07**	

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REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **249,062**	**36** months	**08/01/07**	

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Project Summary

Representations for Visualizing Collaborative Knowledge Construction in Technology-mediated Learning Environments

The increasing prevalence of technology-mediated collaborative learning demands an understanding of how participants appropriate and are influenced by the affordances of the technology. We do not adequately understand how learning is accomplished through participation in such settings. Furthermore, innovative educational approaches that take advantage of recently developed socio-cultural principles and technologies are too complex to rely upon any single method of research and evaluation. It is necessary to synthesize the findings of multiple investigative and analytic methodologies through give-and-take among researchers involved in studying and designing for collaborative inquiry. A key question in understanding technology-mediated learning environments is how the technology influences collaborative learning processes and how participants make choices about how the technology is used. To meet these needs, we need to examine technology-mediated collaborative learning that is distributed across time, people and technological tools, and uncover how groups' ideas unfold over time.

The primary goal of the proposed work is to improve our understanding of and designs for technology-mediated collaborative learning. The instrumental objective is to improve methods for analysis of mediated interaction, filling the middle ground between scaleable "quantitative" methods (such as coding and statistical approaches to analyzing verbal data) and high fidelity "qualitative" methodologies (e.g., microanalytic techniques such as conversation analysis) while also developing a synergy between existing methodologies. Although analysis of online learning is the challenge that motivates this work, analysis of technology-supported face-to-face learning is also part of the scope. This project will synthesize methodologies including conversation analysis adapted for chat-mediated interaction, analysis based on tracing out mediated uptake and analyses of co-occurring patterns of problem solving, conceptual change and media use. It will create tools for building graphical representations of the knowledge-construction process, to support different grain sizes of analysis and to promote dialogue among researchers.

Intellectual Merit. The proposed work addresses the critical need for analytic methods that provide both scalability and fidelity. It builds on prior work in representational affordances for collaboration, group cognition and problem-based learning in complex domains. To support taking analysis of interaction to scale, software tools will be developed that visualize the chronological and uptake structure of interaction in the context of media appropriations. Advances will be made in analysis methods, tool design and results informing educational practice. This empirical research and evaluation project is grounded in the STEM disciplines of mathematics, aquarium ecosystems and computer science. It has strong potential for contributing to theory, methodology, and practice, addressing leading-edge issues of importance in advancing research and evaluation of learning in STEM disciplines. The PIs in the project are leaders in the field of computer-supported collaborative learning, who have made significant theoretical, methodological and practical contributions to the field.

Broader Impact. From technology-supported interventions in K-12 classrooms to university-level online classes, learning is increasingly being supported by technology. Because learning is largely social, it is critical to understand how group processes lead to collaborative learning. This is important in being able to provide educational opportunities to all learners, particularly those from traditionally underserved groups. The tools and techniques we develop will have an important impact on the research practices of the field, and ultimately can be used to develop a better understanding of designing effective collaborative learning environments in diverse STEM disciplines not limited to those studied in this project. This work will be disseminated through invitational data-fests and public workshops as well as through a project website. Traditional academic dissemination methods will also be fully utilized.

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Project Narrative

From technology-supported interventions in K-12 STEM classrooms to university-level online learning, learning is increasingly being mediated or supported by technology (Allen & Seaman, 2005; Bichelmeyer & Molenda, 2006; Orey, McClendon, & Branch, 2006; Podoll & Randle, 2005). Because learning is largely social, it is critical to understand how collaborative processes can lead to learning (Barron, 2000; Greeno, 2006). Additionally, in technology-mediated settings an understanding of how participants appropriate and are influenced by the affordances of the medium is needed to adequately inform the design of the learning environment (Hmelo-Silver & Chernobilsky, 2004; Hoadley & Pea, 2002; Suthers, 2006b). However, too little is understood about how learning takes place under computer-supported conditions to take advantage of the collaborative-learning potential of networking students. Researchers lack the analytic tools and methodologies that they need to study how learners enact and understand their technological environments and to develop effective approaches to online collaborative learning. Within the learning sciences generally and within the field of Computer-supported Collaborative Learning (CSCL) specifically, theories, tools, methodologies and pedagogical practices have been imported from face-to-face and teacher-centric contexts, often failing to meet the needs of this timely research field.

Project Objectives

The motivating goal of the proposed work is to achieve advances in understanding and designing for computer-mediated collaborative learning. The focused project objective is to improve methods for analysis of mediated interaction, filling the middle ground between scaleable "quantitative" methods and high fidelity "qualitative" methodologies while also fostering dialogue between these existing methodologies. Although analysis of online learning is the challenge that motivates this work, analysis of face-to-face learning that is supported by technology is also part of its scope. The proposed work addresses the critical need for analytic methods that provide both scalability and fidelity.

This project builds on prior work at three American CSCL research labs addressing representational affordances for collaboration (Suthers), group cognition (Stahl) and problem-based learning in complex domains (Hmelo-Silver). Analytically, the project will synthesize methodologies including conversation analysis adapted to chat-mediated interaction (Stahl), analysis based on tracing out mediated uptake (Suthers) and analyses of co-occurring patterns of conceptual change, problem solving and media use (Hmelo-Silver). It will do this work in part through data-analysis sessions in which the three labs and invited researchers examine each other's data through their own methodological lenses.

The sources of data include comprehensive records of learners engaging in mathematics via an online learning environment using synchronous text chat and a shared whiteboard (Stahl), video data of students using computer models of freshwater aquatic ecosystems (Hmelo-Silver), studies of dyads investigating a complex public health problem mediated by a variety of discussion and evidence modeling tools (Suthers), and blended learning in postsecondary computer and information sciences (Suthers). In order to support taking analysis of interaction to scale, the project will develop software tools that visualize the uptake structure of mediated interaction and support analysis through multiple theoretical lenses.

Methodologically, the project will be a success if each participating research lab improves its analytic practices as a result of having interacted with each other, and the project offers an improved analytic toolkit to the research community. The project goal is not necessarily a single unified analysis methodology—rather, strengths, limitations and potential complementarities of different approaches will be identified. Educationally, the project will be a success if the analytic improvements lead to advances in our understanding of methods that students use to achieve understanding in CSCL environments and the design considerations that affect their success. These findings will be oriented to inform design of CSCL environments and pedagogies.

Intellectual Merit

The major practical issue facing the field of CSCL is how to overcome the disjunction between different research paradigms (e.g., design-based research, ethnomethodology, and experimentalism), and their

associated analytic methodologies. This project will bring together three leading American CSCL research labs to collaborate on the intertwining of their approaches and on the joint development of practical tools for analysis and visualization of small-group interaction and collaborative learning among students. The project data is firmly based in the STEM disciplines of mathematics, freshwater ecosystems, epidemiology, and computer science, with potential extension to marine ecosystem science. Project work will address leading-edge issues in theoretical, methodological, and representational aspects important to advancing research and evaluation of how technology-enhanced learning takes place in STEM disciplines. Advances will be made both in analysis methods and in results informing educational practice that these methods enable.

The PIs of the project are recognized leaders of the research field of CSCL. They have each organized international CSCL conferences (2002, 2005, 2007) and have made significant theoretical, methodological and practical contributions to the field. Specifically, Hmelo-Silver, Stahl and Suthers have promoted the concepts of collaborative knowledge building, group cognition and intersubjective meaning making, respectively. Methodologically, they have used a variety of quantitative and qualitative approaches. Although they have interacted together informally for some time and recently more formally as part of a Science of Learning Center Catalyst grant, this project will allow them to intertwine their efforts systematically.

Broader Impact

Objectives will be achieved and disseminated through four forms of participation: within laboratory, between laboratory, invitational data-fests, and public events such as workshops. First, members of each PI's laboratory will conduct intensive analytic work on their own data and continue to refine their analytic methods while drawing on insights gained through the other forms of participation. Second, close collaboration between the PIs' labs will be supported by bi-monthly videoconferencing to share analysis methods, as well as face-to-face workshops each year providing the opportunity to analyze each other's data in depth. Third, other researchers active in developing methods for analysis of CSCL will be invited to "data-fests," providing new perspectives as well as serving as a form of dissemination of proposed tools and insights to date. Fourth, two workshops per year will be held at an appropriate conference to enable other researchers to learn about and contribute to this work in a hands-on manner (at the international CSCL and ICLS conferences) and to bring project insights to practitioners (at AERA). Traditional academic dissemination methods will also be fully utilized. Tools developed in the project will be disseminated at these workshops and through a project website. These tools and techniques will have an important impact on the research practices of the field, and ultimately can be used to inform the design of effective collaborative learning environments. The collaboration among the three research labs will provide a model of synthesis and complementarity of methods for the field of CSCL. The data-fests and workshops will be important steps to widening this process within the research community.

Theoretical Perspectives on Computer-supported Collaborative Learning

Although we believe that the methodologies we develop in this work will be valuable for analyses under a variety of views of learning, it is worth noting how the methodology is motivated by our own views of how learning takes place in social settings. Learning in collaboration with others is the foundation of CSCL, yet many different theories exist concerning how social interaction leads to learning. We conceive of *all* learning as not merely the sharing of information between learners, but also as an *interactional process* of change. This conception is compatible with theories of learning that identify socially embedded individuals (Doise & Mugny, 1984; Vygotsky, 1978), social systems (Engestrom, 2001), or communities (Wenger, 1998) as the locus of change. An interactional view of learning is also consistent with research on individual learning, such as reading (Beck, 1997) and solving physics problems (Chi, Bassok, Lewis, Reimann, & Glaser, 1989).

Knowledge-building communities (Hmelo-Silver, 2006; Scardamalia & Bereiter, 1991, in press) expand their knowledge capital through the collective development and continual improvement of conceptual artifacts such as theories and cultural understandings. In small groups, knowledge building

takes place through processes of *group cognition* (Hutchins, 1995; Pea, 1993; Stahl, 2006a). The discourse among several people can accomplish the likes of mathematical problem solving, scientific argumentation, medical diagnosis or environmental modeling. At the core of this productive discourse is collaborative interactions that serve to define and maintain a shared topic and to establish shared meanings for the group (Roschelle & Teasley, 1995; Suthers, 2006b; Wertsch, 1985).

Given that learning often involves the internalization of understandings and practices that originate in the social realm (Vygotsky, 1978) we can expect to find the origins of learning, particularly collaborative learning, in the social processes in which these understandings and practices originate. To understand how learning is accomplished in social settings we must study the practices of *intersubjective meaning-making* (Koschmann, 2002; Stahl, 2006a; Suthers, 2006b): how people in groups make sense of situations and of each other as they participate "in the wild" (Hutchins & Klausen, 1996; Lave & Wenger, 1991). Learning takes place when participants' "continued attempt to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p.70) is internalized as new skills and understandings (Vygotsky, 1978). This process is mediated by the physical and social environment in diverse ways (Engestrom, 2001; Hutchins & Klausen, 1996; Wenger, 1998). As designers of media for online learning, mediation gives us an avenue for influencing learning through the affordances of the tools that we design for social acts of meaning-making (Resnick, 2002; Wartofsky, 1979).

Methodological Perspectives on Computer-supported Collaborative Learning

Efforts to develop innovative educational approaches that take advantage of socio-cultural principles (Cole & Engeström, 1993) and technological innovations are too complex to rely upon any single method of research and evaluation (Erickson, 2006; Hmelo-Silver, 2003; Stahl, Koschmann, & Suthers, 2006). It is necessary to synthesize the findings of multiple investigative and analytic methodologies—not just retrospectively in high-level reviews, but through reciprocal interaction among researchers involved in collaborative inquiry. For instance, a narrative description can spark a quantitative comparison of cases, followed by a micro-analysis of interactional processes. A model of social practices in a community can inform the understanding of small-group activities, which in turn result in individual learning outcomes—requiring complementary methods at different levels of analysis. The ability to apply multiple methods may exceed the capacity of any one small research lab. However, through collaborative research, different methodologies can be applied to data sets from multiple labs, allowing systematic examinations of the advantages and limitations of different approaches.

Many studies use analysis methods that assign meaning to interaction segments in isolation through coding and then aggregate these codes through counting (e.g., Chi, 1997; De Wever, Schellens, Valcke, & Van Keer, 2006; Rourke, Anderson, Garrison, & Archer, 2001). Methodologies based on aggregated measures offer advantages, including measures of consistency between analysts, statistical tools for testing the effect of an intervention by comparing multiple sources of data, and relative ease of scaling to larger data-sets. However, such methods place the researcher at a distance from the actual practices by which learners make use of the technology, making it difficult to evaluate the role of specific properties of the technology or to investigate issues that were not anticipated in advance (Koschmann et al., 2005). A key question in understanding technology-mediated learning environments is how the technology influences collaborative learning processes and how participants make choices about how the technology is used. This requires analyzing how technology-mediated collaborative learning is distributed across time, people and different technological tools, and examining how groups' ideas unfold over time. We believe that complementary methods are needed to understand how learning is accomplished through interaction, how learners engage in knowledge building, and how designed media support this accomplishment (Bransford, 1999; Erickson, 2006).

Several analytic traditions exist that can bear on this problem, particularly micro-analytic methods such as Conversation Analysis and Interaction Analysis (Goodwin & Heritage, 1990; Jordan & Henderson, 1995). Many of these methods draw upon the ethnomethodological assertion that order emerges from the participants' interaction (Garfinkel, 1996). Typically, video or transcripts of naturally

occurring interactions are studied to uncover the methods by which participants accomplish their objectives. For examples applied to the analysis of learning, see Baker (2003), Roschelle (1992), Koschmann et al. (2003), and Koschmann, et al. (2005). This paradigm is becoming increasingly important in CSCL because an approach that focuses on accomplishment through interaction is necessary to truly understand the role of technology affordances (Stahl, Koschmann et al., 2006; Suthers, 2006b).

A potential limitation of these methods is their typical focus on brief episodes of face-to-face data; they may not scale well to online learning where media resources, time scale and synchronicity all differ. In general, analytic methods are often tied to the properties of a specific medium. Sequential analysis methods (Sanderson & Fisher, 1994) are promising, although they share some of the limitations of statistical methods and need to be adapted to the needs of education. The analytic tradeoff between scalability and fidelity must be resolved in order to inform the design of improved learning environments and participation structures that engage learners during collaborative inquiry. Researchers need to understand not only interactive processes but also the role different technological tools play in computer-supported collaborative learning.

Trying to understand the complexity of technology-mediated learning environments often requires integrating multiple data sources. As Larkin and Simon (1987) noted, a diagram is often much easier to interpret than verbal presentations of the same material, and this is particularly true for researchers trying to integrate data that is distributed over time, people and tools. For example, Martinez, Dimitriadis, Rubis, Gomez & de la Fuente (2003) conducted a mixed methods analysis using quantitative measures, social network analysis, and qualitative description. Although their sociogram showed interaction patterns, it was not easily integrated with other sources of data (though it helped in their interpretation). Strom, Kemeny, Lehrer, & Forman (2001) used directed graphs to map the semantic space of the instructional discourse as students coordinated conceptual and procedural knowledge. Luckin (2003) adapted the CORDFU methodology to study children collaborating around multimedia. Hmelo-Silver & Chernobilsky (2004; Hmelo-Silver, Chernobilsky, & Mastov, 2006) generalized this methodology in creating chronologically-oriented representations of discourse and tool-related activities (CORDTRA) to examine tool-mediated collaborative processes in the online STELLAR environment by creating parallel timelines of coded discourse and log file data. Suthers (2006a) used visual representations to create uptake graphs that show how learners build on prior contributions in both synchronous and asynchronous online collaboration. Stahl (2005; Stahl, submitted) has begun to diagram relationships that are constitutive for meaning making in group cognition. A specific goal of the project is to create tools that will allow the building of graphical representations of the collaborative knowledge construction process that will support different grain sizes of analysis and promote dialogue among researchers taking different approaches to analyzing these phenomena.

Intertwining of Research

The PIs' three laboratories collectively have experience with a diversity of methodologies needed to understand technology-mediated collaborative learning, and in some cases have experimented with both mixed methods and methodological fusions. Our strategy for building on this experience is to (1) strengthen the analytic work in each of our individuals labs; (2) collaborate intensively to synergize our approaches, and (3) provide participation structures to both draw upon the expertise of and bring our own work to the broader CSCL research community. The following subsections discuss (1) each of the three research labs collaborating on this project, including the results of prior NSF support on which we build. The next section will discuss our strategies for (2) collaborating and (3) involving the CSCL community.

Lab #1: Drexel (Stahl): The Virtual Math Teams Lab

The Virtual Math Teams Project (VMT) is a CSCL research lab associated with the Math Forum at Drexel in Philadelphia. The VMT team has proposed, designed, developed, tested and analyzed the use of the VMT service at the Math Forum. The VMT service provides opportunities for learners of mathematics in the US and around the world to meet online and to collaboratively discuss a choice of math problems and open-ended issues. The service includes an online environment combining text chat and a shared

whiteboard, supplemented with various tools. It also provides support for teachers who want to involve their students. Although still in a development phase, the VMT service has been used under a range of conditions, from early elementary school in US urban settings to junior college in Singapore.

The VMT team meets weekly to analyze transcripts from online math sessions. PI Stahl provides the project with a coherent research direction. Math Forum Director Weimar informs the process with math pedagogy expertise and experience in collaborative learning. Ethnomethodologist Zemel leads the team in a rigorous analytic methodology, transferred from conversation analysis to the analysis of text-based interaction. The project has gradually developed a sense of how to pursue theoretical and technology-related research questions through design-based research, iterative cycles of software development, programmatic interventions and analytic inquiries. From intense microanalysis of brief interactions, the team is compiling knowledge of how collaborative learning takes place in CSCL environments like VMT. It is gradually amassing collections of similar excerpts and looking at longer time segments in order to generalize and extend its findings. Over 50 publications have already come out of the VMT project and many more are in the works (see http://www.mathforum.org/vmt/researchers/publications.html), including at least six PhD dissertations.

For some time, we have been trying to work out structures of collaborative meaning making. At ICLS 2000, we presented a model of collaborative knowledge building (Stahl, 2006a, Ch. 9), followed at CSCL 2002 with a theoretical framework for CSCL (Stahl, 2006a). In an extended analysis of building collaborative knowing illustrated with SimRocket data, we presented elements of a social theory of CSCL centered on meaning making (Stahl, 2006a). We subsequently distinguished between interpretation from individual perspectives and meaning as shared and embodied in artifacts in the world in a CSCL 2003 paper (Stahl, 2006a). At CSCL 2005, we argued that groups can think—that they can have cognitive agency (Stahl, 2006a). The book on *Group Cognition* (Stahl, 2006a) develops this notion that small groups of learners—particularly with the support of carefully crafted digital environments—have the potential to achieve cognitive acts, such as mathematical problem solving. Here, the term "group cognition" does not refer to some kind of mental object, but to the ability of groups to engage in linguistic processes that can produce results that would be termed "cognitive" if achieved by an individual. Group cognition in principle cannot be reduced to mental representations of an individual or of a sum of individuals. The theory of group cognition is similar to theories of distributed cognition (Hutchins, 1995), but the emphasis is more on distribution among people rather than with artifacts, and the cognitive accomplishments are high-order tasks like math problem solving rather than routine symbol manipulations.

Recently, the VMT lab has been investigating specific structures of meaning-making practices, analyzing online interactions among math students. For instance, we characterized "math-proposal adjacency pairs" (Stahl, Zemel et al., 2006), looked at how a group could solve a math problem that none of its members could solve (Stahl, 2006b), and investigated how students used a referencing tool in our environment (Stahl, 2006a). We closely analyze brief interactions in well-documented case studies to determine the social practices or methods that groups use to accomplish their meaning making. Thereby, we seek to determine structures of small-group cognitive processes. We believe that the foundation of CSCL as a unique field of study is the investigation of the meaning-making processes that take place in online collaborative settings. The analysis of group cognition is not the whole story; one can, of course, also analyze individual learning and other psychological phenomena or larger activity structures and communities-of-practice, but the processes of small-group interaction are of particular centrality to collaborative learning.

Results from Prior NSF Support of the VMT Lab

"IERI: Catalyzing & Nurturing Online Workgroups to Power Virtual Learning Communities." *Award IERI 0325447; NSF IERI Program; $2,300,00; 5 years commencing September 1, 2003.* Presently about half over, this project has completed several iterations of design, development, testing and analysis of the Virtual Math Teams service at the Math Forum. Over 1,000 student-sessions have taken place, averaging an hour. Six doctoral students are working on dissertations based on data from this project.

Software for the VMT environment is being released as Open Source and is being used by other researchers in collaboration with this project. A methodology for the analysis of online collaborative learning has been developed, called "chat analysis". A replayer tool has been developed to provide adequate access by researchers to the sequentially unfolding interactions in the VMT environment's chat and whiteboard spaces. Several key features of online collaborative learning have been analyzed using a graphical representation of interaction threading.

"Engaged Learning in Online Communities." *Award SBE-0518477. NSF Science of Learning Center Catalyst Program; $180,762; 2 years commencing October 1, 2005*. This project brings together interdisciplinary researchers interested in how to promote online communities for collaborative learning. The original intention was to build the foundation for an NSF Sciences of Learning Center. The project now aims to generate smaller scale collaborations among research labs, both nationally and internationally, including this proposed project. Through a series of PI meetings and public workshops, the following signature challenges were identified: (1) How to deepen the learning that takes place, given that most current examples of successful engaged learning in online communities remain shallow. (2) How to introduce inquiry learning in student-centered informal online communities into social contexts dominated by formal schooling. (3) How to integrate pedagogical scaffolding, technological affordances and motivational sociability into coherent and engaging programs and services.

Work-Plan for the VMT Lab

We have seen that an understanding of the intersubjective meaning-making process of a small group in a text-chat environment involves paying attention to an intricate web of connections among the items in the interaction record and items from the context that are made relevant in the discourse. There is a *threading* of the flow, with a particular posting following up on a preceding one (that may not be immediately adjacent in the chat log) and opening the possibility of certain kinds of postings to follow. There is *uptake* of one phrase or action by another, carrying the work of the group ahead. There are often important *continuities* from one posting of a particular individual to the same person's subsequent postings. Various sorts of communication problems can arise—from typos to confusion—and *repairs* can be initiated to overcome the problems. Lines of chat can *reference* items outside the chat, such as whiteboard drawings, formulae learned in the past or notions raised earlier. Terms and phrases in a posting can serve as *citations* of previous statements, making the former meanings once more present and relevant.

The proposed project will extend and deepen this research. The VMT environment includes a shared whiteboard and optionally also a wiki space. Representations that include activities in these coordinated with the chat log graph will further aid analysis of collaborative activity in such rich digital learning environments. The development of flexible graphical representations and of our analytic methodology will mutually inform each other. Together, they will lead to the elaboration of an approach to the analysis of collaborative learning that can be disseminated to other researchers. From the VMT side of the collaborative effort, each year we will select at least six sessions of online math work by students in the VMT environment for joint analysis as part of this project. All researchers in the project will have access to these sessions in the VMT Replayer, so they can experience and analyze the sessions, observing all the chat messages, whiteboard activities, wiki postings and social awareness notices—just as the student participants originally observed them. We will develop graphical representations for visualizing the network of relationships that we believe are definitive of meaning making as it unfolds in situations of online collaborative learning. For instance, we can present a chat log with each participant's contributions in a different column. Then we can layer networks of arrows reflecting threading, uptake, continuity, repair, reference and citation, similar to (Suthers, 2006a). The resulting web would provide a representation for visualizing the co-construction of shared meaning and for guiding the analysis of collaborative knowledge building. By generating such representations digitally, we can support researchers manipulating and sharing different perspectives on the chat history. By working collaboratively on data from Hawai`i, Rutgers and Drexel, we will gain experience in broadening the applicability of our approach.

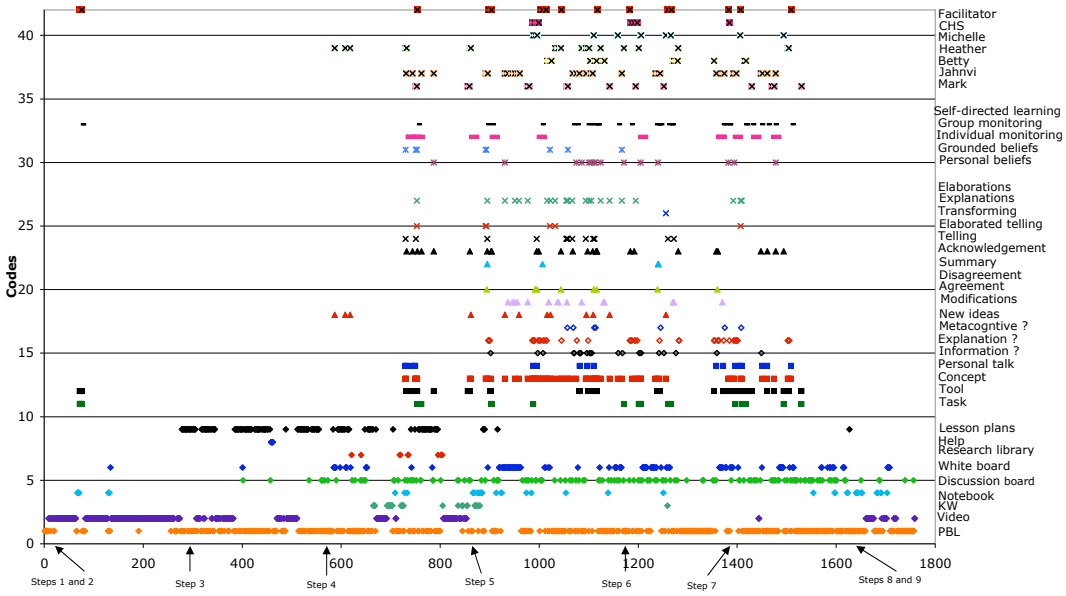

Figure 1. CORDTRA diagram (Derry et al., 2006)

Lab #2: Rutgers (Hmelo-Silver): The RepTools Lab

The RepTools Lab has focused on the use of representations in two ways. First, the RepTools team embeds conceptual representations into technology-mediated learning environments to support deep science learning. In this project, they have used the Structure-Behavior-Function (SBF) conceptual representation (Goel et al., 1996) to help students learn about complex biological systems (Liu & Hmelo-Silver, 2007; Liu, Hmelo-Silver, & Marathe, 2005; Liu, Marathe, & Hmelo-Silver, 2006). We have designed a suite of multimedia and simulation tools in two complex systems domains. The RepTools team engages in mixed methods analyses of both learning outcomes and collaborative knowledge construction processes. Directed by Hmelo-Silver, the RepTools team meets regularly to discuss analytic strategies, such as the development of coding schemes as well as working jointly on interaction analysis. These data analyses feed into an ongoing cycle of design research that will be used to inform future educational interventions.

Second, the RepTools team is interested in how they can use representations to help make sense of technology-mediated learning. Understanding how tools are used to mediate interactional practices in technology-mediated collaborative learning requires examining discourse data as well as data on how learners use different kinds of tools. These different data sources cannot be studied in isolation. The RepTools team has been exploring the use of chronologically-oriented representations of discourse and tool related activity (CORDTRA) in asynchronous discussion groups during problem-based learning in the STELLAR system (e.g., Chernobilsky, Nagarajan, & Hmelo-Silver, 2005; Hmelo-Silver & Chernobilsky, 2004; Hmelo-Silver et al., 2006). The initial work with CORDTRA representations was developed as part of an earlier NSF-funded project. CORDTRA creates parallel timelines of coded discourse and computer logs that allow us to visualize discourse events and tool use simultaneously, as shown in Figure 1. These representations allow us to understand possible roles that tools and artifacts have in mediating collaborative knowledge building, and have been used in our work to understand the differences between more and less successful groups. Moreover, CORDTRA supports analysis of collaborative activity at multiple time scales, which has proven extremely valuable. One can get the big picture by looking at a CORDTRA diagram over several days, which may then provide suggestions for where to zoom in on interesting interactive events. The CORDTRA technique, while very illuminating, is

very labor intensive to manually construct. It does not show how discourse and tools are directly connected, e.g., what ideas are taken up. Work with our project partners will address these issues.

Results from Prior NSF Support of the Rutgers Lab

"Video Cases Online: Cognitive Studies of Preservice Teacher Learning" *ROLE #0107032; PI Sharon Derry and co-PI Cindy Hmelo-Silver; $1,384,000; 2001-2005.* This project developed and tested the STELLAR system to support teacher learning from video cases, an integrated learning sciences hypermedia, and an online problem-based learning structure for CSCL. Results demonstrated superior learning outcomes for students. During this project, the CORDTRA methodology was developed.

"Representational Tools to Support Understanding of Complex Biological Systems" *ROLE # 0133533; CAREER program; 2002–2008; $599,000.* The primary goals of this grant are to understand (a) whether SBF models provide an adequate account of expert understanding, (b) how providing an explicit external representation supports development of a conceptual representation, and (c) how dynamic representational tools support learning. A study of expert-novice differences in two domains found that SBF models act as a conceptual representation associated with expertise. The RepTools suite of hypermedia and simulations for two complex systems domains has been created. Two studies that embed SBF in hypermedia for middle school students and pre-service teachers showed that this external representation supports development of conceptual representations. We have worked with 300 middle school children using NetLogo models of the aquariums and human respiratory system. Our research demonstrated significant improvement in student understanding.

"Learning about Causal Models in Complex Domains" *SBE# 0350342, SLC catalyst program; PIs: Ashok Goel, Cindy Hmelo-Silver, Teresa Hubscher-Young, N. Hari Narayanan, and Sadhana Puntambekar; October 2003 - March 2007; $194,000.* The primary goals of this project are to (a) conduct a survey of pedagogical techniques for learning causal models in science and engineering (b) analyze the teaching and learning techniques in terms of SBF models and (c) use SBF models as a basis to formulate a research agenda for advancing computational technology for learning causal models of physical systems. We have conducted a survey of pedagogical techniques for learning about complex causal systems in STEM domains.

Work-Plan for the Rutgers Lab

In our prior work, we have come to appreciate the importance of understanding sequential relationships among connected discourse and their relation to technology. Our goal is to take this further, to understand how it relates to collaborative knowledge building. In this project, we will focus on data collected as part of NSF funded projects of middle school children learning about complex ideas using hypermedia and Netlogo models of freshwater aquaria using data collected as part of Hmelo-Silver's NSF CAREER RepTools project and that will be collected in the future as part of an ALT project using a structure-behavior function modeling tool. Both of these projects provide a large corpus of data of children working in technology-rich environments that provide representational tools for thinking about a complex domain (approximately 20 groups of 4-6 children). Some of these data are being analyzed using mixed quantitative (coding) and qualitative methods. Thus we will be able to contrast the analytic affordances of different methodologies.

In this project, the existing coding schemes will be reviewed for their utility in studying how technology facilitates collaborative knowledge building. In addition, we will enrich the coding to include all tool related actions—interactions with or references to NetLogo simulations, hypermedia, and other representations that students develop as they are engaging in collaborative knowledge building. We will generalize our CORDTRA methods to study synchronous co-located groups of middle school children, and develop software tools that will facilitate constructing the CORDTRA representations. These representations will be integrated with Suthers' uptake analysis to address how ideas get incorporated from the discourse and mediated by the tools themselves as part of knowledge building activity, and to support Stahl's fine-grained approach to analyzing group cognition. In addition, we will examine how well the CORDTRA plus uptake analyses help in understanding data from the three laboratories. Through these methods, we expect to be able to provide more semantically meaningful indicators of knowledge

building. Finally, we have pre and post measures for our data, so we can examine how group cognition relates to individual learning outcomes.

Lab #3: U. of Hawaii (Suthers): The Laboratory for Interactive Learning Technologies

The Laboratory for Interactive Learning Technologies (LILT) has since its inception in 1998 been centrally concerned with representational mediation and guidance of collaborative learning, with research ranging from the meaning-making dialogues of small groups to supporting reflective practice in online communities. There are currently two major projects in LILT: Collaborative Representations (CollabReps), and Hawai`i Networked Learning Communities (HNLC). CollabReps is most relevant to this proposal, although HNLC provides a source of data. Below we describe the ongoing work of the laboratory in the context of the results of these projects

Results from Prior NSF Support of LILT

"Collaborative Representations: Supporting Online Knowledge-building Discourse." *Award CAREER 0093505, April 15, 2001-March 31, 2007, $402,755.* The Collaborative Representations (CollabReps) project examines how participants appropriate and are influenced by the affordances of collaborative learning software and develops strategies for embedding such technologies in educational practice. The project began with experimental studies of "representational guidance" (Suthers, 2001), funded initially by the KDI/LIS program and subsequently by the present CAREER grant. The first set of results demonstrated that it is possible to predict how representational notations used by co-located learners will influence their collaborative processes (Suthers & Hundhausen, 2003; Suthers, Hundhausen, & Girardeau, 2003). Subsequently we began to study online interaction, finding that graphical representations are used as part of the discourse medium in interesting ways discussed in (Suthers, Girardeau, & Hundhausen, 2003). More recent work has studied how conceptually explicit representations (in this case, evidence maps) can foster improved collaborative knowledge building as compared to threaded discussions typical of online learning. Findings include better performance on high integration questions and greater convergence when conceptual representations are used (Suthers, Vatrapu, Medina, Joseph, & Dwyer, in press). Further analysis showed that users of conceptual representations engage in more "round trip" interaction beyond information sharing (Suthers, Medina, Vatrapu, & Dwyer, submitted).

Many of these analyses followed the quantitative paradigm of coding followed by statistical analyses. Since we want to understand how learners actually use the resources of the technology media to learn through collaboration, we realized that we needed to take a closer look at actual instances of collaboration, and that a methodology that retains the interactional structure of the data was needed (as discussed earlier in this proposal). Towards this end, during the past two years we have developed an approach to analysis that is based on an abstract transcript of the interaction. The method is based on the concept of "uptake": the act of one participant taking up and building on a prior contribution. Uptake can take place both intersubjectively (between two different participants) and intrasubjectively (a participant building on her prior work), so this unit of analysis supports both analyses of individual learning trajectories and how these individual trajectories may intertwine with those of other participants. An analysis of uptake in synchronous online interaction showed that conversation-like structures such as arguments and co-construction of solutions can be discerned in participant's actions in an evidence mapping workspace as well as linguistically expressed in a chat tool (Suthers, 2006a).

The analytic representations used in that study (columns for each participant with arrows indicating uptake) were specific to synchronously interacting dyads. We sought a more general notation to handle larger numbers of participants, asynchronous as well as synchronous interaction, and/or different kinds of media. We also sought to separate the evidence for uptake found in the data from the judgment that uptake has taken place. This led to the development of a *dependency graph* notation (Suthers, Dwyer, Vatrapu, & Medina, 2007). The dependency graph captures different ways in which a given act can be related to prior acts that suggest there may be uptake. Importantly, acts of perception (e.g., reading someone's message) as well as contributions (e.g., posting a message) must be included in the dependency graph to trace out the evidence for uptake. The acts are vertices in the graph and the dependencies are arcs

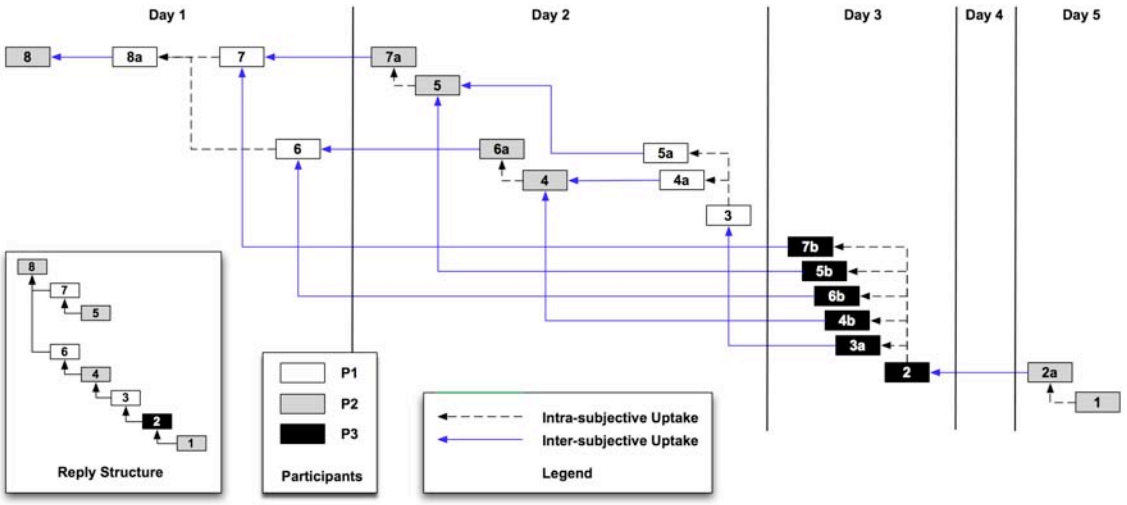

Figure 2. The uptake graph for a threaded discussion exposes interaction not visible in reply structure (see inset), identifying role of participant 2 as integrator. Nodes with letters are reads.

(see Figure 2). The most straightforward dependencies are *media dependencies*: a participant acts on an object that was previously created or manipulated (e.g., reading a message in a threaded discussion, or editing or linking to an object in a concept map). Somewhat more circumstantial evidence includes *temporal proximity* (e.g., posting a message immediately after reading another message that need not be in the same thread), *spatial proximity* (e.g., grouping objects together in a manner suggesting relatedness), and *linguistic coherence* (e.g., reuse of the same descriptive phrase as in a message recently read). Once dependencies between participants' acts have been identified, the analyst can use the graph to make judgments concerning the evidence for uptake. We have used dependency graphs to analyze episodes from our laboratory studies of asynchronous interaction through evidence maps and threaded discussion, identifying how participants achieve agreement on important issues, and also to analyze online discussion in a graduate seminar course (Suthers et al., 2007). Also, in a synthetic methodology we have used interactional patterns found in dependency graphs as a measure in a quantitative comparison mentioned previously (Suthers et al., submitted).

Collaborative Representations research has also included an exploratory study identifying methods of collaboration through written media that are invariant across different media (Dwyer & Suthers, 2005); a study of strategies for the use of evidence mapping in a middle school classroom (in preparation); and an agenda-setting analysis of the field of Computer-Supported Collaborative Learning (Suthers, 2006b). This history provides our laboratory with significant intellectual capital and human resources for the proposed work. This project has graduated two Masters' students and currently involves three Ph.D. students who are significant collaborators in the development of analysis methods, all of whom have gained various mixtures of skills in educational and social research applied to computer science.

**"Hawai`i Networked Learning Communities."** *NSF RSI Cooperative Agreement #0100393, July 1, 2001-June 30, 2007, $6,134,444 (awarded to Hawai`i Department of Education with a subcontract of $1,234,732 to LILT).* HNLC is a Rural Systemic Initiative, also in its no-cost extension year. LILT's role as a subcontractor has been to develop a software environment for a distributed community of Hawai`i educators, supporting the Hawai`i DOE professional development efforts and enabling educators to collaborate and share resources across our island state. The resulting virtual community center, hnlc.org, has hundreds of educator members with several dozen currently active online in professional development and other activities. This software base has also been reconfigured (as disCourse.ics.hawaii.edu) to support a community-oriented model of online learning in the PI's graduate program. Published research on this grant has focused primarily on the role of technology in systemic reform (Suthers et al., 2004) and

in mediating relationships between partners to that reform (Suthers, Yukawa, & Harada, 2006; Yukawa, Suthers, & Harada, submitted), as well as telementoring (Yukawa, 2005). We currently are studying how the hnlc.org and disCourse environments afford the formation of new social relationships between participants, applying methods of sequential analysis (Olson, Herbsleb, & Rueter, 1994; Sanderson & Fisher, 1994) and social network analysis (Wasserman & Faust, 1994). These software-supported communities provide substantial data for testing the scale-up of our analytic methods.

Work Plan

Dr. Suthers and his students will play two related roles in this project: continuing our own investigations of the analysis of technology-mediated collaborative knowledge construction, and building software tools that support this analysis and can also be used by others:

Analysis of Technology Affordances for Collaborative Knowledge Construction. Continuing the research agenda and applying the analytic approach described above, under this grant, LILT will analyze data from at least two sources to investigate how participants both appropriate and are guided by the visible affordances (potentials for action) of designed media. Initially we will work with the extensive data we have from laboratory studies of dyads interacting asynchronously through threaded discussions and evidence maps. Participants grappled with the ambiguous cause of amyotrophic lateral sclerosis/Parkinsonism dementia complex (ALS/PDC) among the Chamorro people of Guam. For over 60 years the medical community has examined multiple hypotheses concerning the disease agent and the vector for introduction into humans. This existing corpus provides rich opportunities for understanding the choices participants make in using multiple media to grapple with a complex problem.

We will test the generality of the analysis by applying it to a second source of data, the online discussions of teachers in HNLC and of students in our online courses. This application will enable us to test the extent to which automated construction and selective visualizations of dependency graphs coupled with CORDTRA representations can enable us to find productive episodes of interaction for more in-depth analysis. Pending other funding requests, a year into the project we may be in a position to replace either of these sources with new data from secondary school students using representationally rich environments to understand marine ecosystems of the Hawaiian islands.

Tools for Analysis. We have been experimenting with different ways to represent dependency and uptake graphs, both formally as a computer representation and visually to make the relevant structures visible to the analyst. Our next step under the proposed funding will be to fully formalize the computer data formats needed to represent these graphs and to develop software visualization tools for constructing them. The tools will include partial automated construction of graphs from data provided by the software media used by participants, methods of processing the graph derived from Exploratory Sequential Data Analysis (Olson et al., 1994; Sanderson & Fisher, 1994), and tools for visualizing the graph. The dependency graphs will be merged with Hmelo-Silver's CORDTRA representation to achieve an important synergy: CORDTRA allows the analyst to find co-occurrences between episodes of activity at different levels of description, while uptake graphs show how specific acts embedded within these episodes build on prior acts towards construction of new understandings.

There is currently much interest in tools for analysis in both North America and Europe. Our tool-building efforts will be in regular communication and potentially collaboration with those of others (see letters). Carolyn Rose of Carnegie Mellon will make her tools for linguistic analysis available, providing a source of information about dependencies. Andi Harrer and his colleagues in the European collaborative "Computer-based Analysis and Visualization of Collaborative Learning Activities" will also continue to interact with the PI to share tools and approaches to computer-supported analysis. These and several other contacts were made at two recent workshops on analysis conducted by the European Union-funded Kaleidoscope CSCL special interest group, in which the PI presented the uptake analysis methodology.

Plans

In this section we discuss how the independent efforts described in the previous section will be combined in this work, and how we will involve others in the agenda of creating a CSCL analytic toolkit.

Tri-Lab Collaboration

The most important driver towards our objectives will be regular and ongoing dialogue between the participating laboratories. Regular engagement in a shared enterprise is required to sustain a community of practice (Wenger, 1998). Towards this end, we plan regular interactions between our groups and with other researchers. This section discusses our plans for supporting participation through various events and media. Three types of participation are outlined below.

Project Staff

To the extent possible, principal investigators, co-PIs and project-funded graduate students will participate in all project events (e.g., data-fests, videoconferences, workshops, online). These are the "core" members of the community responsible for the work of the project, whether as leaders or apprentices. Other graduate students and researchers in our laboratories will also benefit through participation in events that are held at or accessible from their location.

Invited Researchers

Researchers in the learning sciences and allied fields who are doing closely related work will be invited to participate in both individually intensive and collective ways. Individually, these researchers will be invited to join our analysis sessions on a rotating basis (e.g., a few researchers in a larger data-fest, or one researcher in a videoconference). We will try to schedule this participation in a manner that matches the researcher's strengths with what might be called the project staff's collective zone of proximal development. These researchers will also be invited to participate in conference workshops, and in our online venue for the project community on an ongoing basis.

Other Researchers

Other researchers and Ph.D. students will be invited to submit for participation in workshops held at conferences, and may join our online community. Traditional means of participation ranging from informal conference conversations to dialogue through the research literature will also constitute peripheral forms of participation for these colleagues.

Data-fests

We use the term "data-fest" to refer to daylong events in which researchers share their data and engage in collaborative analysis of that data. In general, data-fests serve multiple objectives related to the learning of the participants and the furtherance of practices in the field. Both established and new researchers become exposed to analytic methods. Researchers obtain a fresh perspective on their data through the eyes of others, possibly leading to new insights. The practices and standards of the field are maintained and replicated, while new analytic perspectives can be introduced to others. In general, data-fests bring participants closer to the practices of participants at all levels than traditional conference or workshop presentations.

Project staff (PIs and their students) and invited researchers (one to three per event to maximize interaction) will participate. These events will typically be held at one of the PI's laboratories. A typical event might begin with brief discussion of the project's current focus; then, most of the time will be spent analyzing several data sets and comparing analyses and tools. A data set might be presented using media recordings (video, audio) where available, session replays in a software medium, transcripts and software logs, and notations such as CORDTRA or the Uptake Graph that provide representations of key features of the learning event being analyzed. Participants will collaboratively analyze the data, each applying an analytic approach of choice. Each analysis might end with a reflective assessment, comparing analytic methods as well as conclusions concerning the given data. At the end of the event, the lead researchers will produce a brief report on the progress made.

It is especially important that the three laboratories continue the work of collaborative analysis between the data-fests. Therefore we will make extensive use of electronically mediated collaboration and other opportunities for interaction with the community. As participants in an NSF-funded Science of Learning Center Catalyst grant, we have already gained experience in collaborating with each other through email, videoconferencing, and web-based workspaces.

Videoconferencing

The work to be undertaken requires that we simultaneously view, reference and discuss various media artifacts such as video, audio, transcripts of various kinds, and analytic data structures. Videoconferencing provides many of the desired interactive affordances for this work. We have already conducted videoconference analysis sessions between the Drexel and UH labs, with others connecting from locations in Madison, Toronto and elsewhere. The videoconferences were conducted using relatively inexpensive video equipment and by sharing digital artifacts over the Internet. We were able to make progress in learning about the analytic work being undertaken in each others' laboratories, importantly engaging our students as well.

Prior to each videoconference, participants will be provided with access to the data to be reviewed and an agenda that identifies the format of the session and the immediate objectives. We will use several alternative formats for these sessions. For example, the objective of a *collaborative analysis* is to bring multiple perspectives on the data, relying in part on the synergy of live interactive analysis. In a *comparative analysis,* each participant prepares an analysis of a productive example in advance, and these analyses are compared and contrasted to eliminate gratuitous differences and identify complementary or incongruous perspectives on the data. In a *problem solving* session, a group presents relevant data and seeks help from the other participants. The purpose of an *analytic critique* is to scrutinize an example analysis presented by one group. We may also conduct *tutorials* or *tool evaluation* on a method or software tool that has been proposed or is being considered by the group.

Videoconference sessions between the labs will generally be scheduled twice a month. This provides each lab with time to make further progress on their own work between videoconferences, but makes the meetings frequent enough to keep the pace of progress high. We do not expect each lab to have new results every 14 days. On a given week, the session may focus on the work of a subset of the labs, so there is more time for a given lab to make new progress. Also, the videoconference sessions will focus on work in progress to offer insights, compare approaches, and help each other with difficulties more than they will focus on "final" results.

Conference Workshops and Symposia

The means of participation discussed above are oriented towards the project staff and their invited collaborators, yet we wish to recruit the participation of other members of the CSCL and learning sciences community in our effort to refine and support the field's emerging research agenda concerning joint practices of meaning-making in technology-mediated settings (Koschmann, 2002; Stahl, Koschmann et al., 2006; Suthers, 2006b). Therefore we plan for means of recruitment, as well as dissemination. Traditional means of academic dissemination will of course be pursued vigorously; but here we focus on interactive forms of participation.

We will submit requests to hold workshops and symposia at the CSCL and ICLS conferences (held in alternate years) as well as at the yearly AERA conference for workshops oriented towards practitioners. These will be "working shops" that will include analytic work like the data-fests in addition to brief orienting presentations and group discussion. Workshops might productively be paired with symposia during the main conference where analytic methods and results can be presented to a larger audience. Such a paired proposal has already been made for CSCL 2007.

Asynchronous Collaboration and Community

In addition to synchronous collaboration in data-fests, videoconferences, and workshops, our work will require ongoing asynchronous interaction. Web-based collaboration will partially fill this need. To maintain control of our collaboration environment and to enable us to instrument our own collaborations, we will continue to use our own online community software. A suite of tools developed by the PI (Suthers) and colleagues to support an online community of teachers (described previously) has also been used to support research collaborations, including the Science of Learning Catalyst led by Stahl (engaged.hnlc.org). The software, which is evolving, currently provides groups with workspaces that integrate wikis, discussion tools, and file sharing, as well as community support functions such as announcements, member profiles and a shared resource database. The environment will support all forms

of asynchronous collaboration among the project staff and invited researchers, such as sharing analyses and tools, and also support preparation and follow-up for the synchronous data-fests, videoconferences and workshops. Workshop participants and other researchers who contact us on their initiative will also be offered membership, to broaden participation in and hence ownership of the methodologies we refine and the research questions that motivate these methodologies.

Supporting Plans

Data-fest Participants and Advisory Board

Leading researchers in CSCL and the Learning Sciences are being recruited as data-fest participants. A subset of these participants will be asked to serve on the advisory board for the additional responsibility of reviewing and advising the projects' progress. The advisory board will be provided with progress reports quarterly and will meet annually with PIs and the evaluator for formative guidance of the project. Letters of commitment obtained to date for participant and advisory roles, as well as other collaborating researchers, are provided in the supplement section.

Evaluation

Evaluation of the project will address the three criteria discussed at the outset of the proposal. (1) Did the participating labs improve their analytic practices as a result of having interacted with each other? (2) Did the project offer an improved analytic toolkit (including methods and software) to the research community, as evidenced by other researchers taking up these tools? (3) Did these advances in analysis lead to results concerning methods that students use to achieve understanding in CSCL environments and the design considerations that affect their success? The project PIs will be responsible for compiling the evidence addressing these three objectives. An external evaluator, Prof. K. Ann Renninger (see letter and bio), will review this evidence and prepare evaluation sections for the annual and final reports to NSF.

Management Plan

Plans for collaboration between the three institutions, already discussed above, will maintain regular informal communication. Here we briefly note formal lines of responsibility and reporting. (1) The regular videoconference analysis sessions and their topics will be scheduled and organized collaboratively between the three PIs, with Suthers bearing the final responsibility to ensure their continuity. Each PI will be responsible for the participation of researchers and students in their laboratory. (2) Data-fests will be held at Drexel or Rutgers to reduce travel costs, and therefore will be organized by Stahl or Hmelo-Silver, respectively, although the three PIs will share responsibility for selecting participants. (3) The PIs will also share responsibility for organizing workshops. (4) The PIs will provide Suthers with quarterly briefings of research and publication progress at each of their respective laboratories. Suthers will compile this material for the advisors and evaluator. One of these briefings will be compiled along with the evaluator's report into the annual NSF report.

Dissemination

The most significant means of dissemination are the data-fests and workshops discussed previously, reaching both researchers and practitioners in a dialogic and hands-on manner. Results addressing the outcomes listed under Evaluation above will also be reported in professional publications.

Timeline

Year 1

The first year is devoted to refining methods within each laboratory, learning to work together, and seeking initial syntheses of methods between the labs. The year begins with a kick-off meeting at which the PIs will develop detailed project plans for the first year and an outline of subsequent years. Although the PIs are already familiar with each other's work, each lab will provide in-depth introduction to its research and methods for the sake of all participants. During the rest of the year, the labs will engage in regular videoconferencing as described previously. Software development will commence at UH to support uptake analysis and to integrate CORDTRA methods. Near the end of the year members of the three labs, the advisory board, and the external evaluator will meet for a data-fest and evaluation of a

prototype of the software tools. The PIs will plan the integration of outside researchers in the second year. A workshop will be held at the ICLS 2008 conference.

Year 2

Face-to-face and videoconference collaboration between the three labs continues in the second year, and a second version of software tools for analysis is prepared and applied to multiple data sets. The participating labs compare research results to seek generalizations concerning learning in the context of technology-mediated collaboration. During this year we will also begin to involve the CSCL research community. Data-fests with invited researchers will be held, and workshops at the AERA 2009 and CSCL 2009 conferences will provide other researchers and practitioners with the opportunity to both inform and benefit from our work. The advisory board and evaluators meet at the end of the year.

Year 3

In the third year, face-to-face and remote collaboration between the labs continue, and data-fests and workshops are held. The emphasis in this year is to evaluate how our tools and techniques can be used by others, to consolidate our own research results concerning the social affordances of technology for collaborative learning, and to disseminate the work more broadly. The advisors and evaluator prepare a summative evaluation for the final report.

Summary

The study of computer-supported collaborative learning has reached a critical juncture. Established paradigms of educational research that black-box the processes by which design interventions have an effect are no longer sufficient. It is time for strategic alliances and syntheses of research methodologies, particularly in the analysis of how learning is accomplished through collaborative interaction in technology-mediated settings. The richness and complexity of the phenomena being studied, and hence of the data with which researchers must grapple, is such that computer support for the analysis itself is needed; support that enables the scale-up of interactional analysis to larger data sets from multiple media and asynchronous as well as synchronous interaction. Our laboratories have experience with a range of experimental, design-based and ethnomethodological methodologies and their associated methods of analysis, and now propose to combine our efforts to address the problems outlined above. Our dialogue will treat the diversity of methods as a resource, identifying how they provide complementary or mutually informing perspectives on the problem of learning through joint activity and forging syntheses where possible. In support of this work, we will develop and explore the use of representations that allow us to study how collaborative learning processes are distributed across time, people and tools. We will build software tools that trace and visualize these processes at different time scales, highlighting different aspects of individual and collaborative learning trajectories. Finally, we will engage the community of CSCL researchers in our enterprise, to develop as well as disseminate our results and promote dialogue between methodological traditions. As a result of this work we expect advances in the scientific study of the relationship between mediating tools and intersubjective processes that lead to designs for more effective group processes leading to enhanced individual learning.

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Professional Preparation

Undergraduate:
Kansas City Art Institute, Photography and Printmaking, Bachelor of Fine Arts, 1979.

Graduate:
Northern Arizona University, Psychology, (M.S. program, ADB), 1982-1985.
University of Massachusetts, Computer Science, M.S. 1988.
University of Massachusetts, Computer Science, Ph.D, 1993.

Appointments

2003-present: Associate Professor, Dept. of Information and Computer Sciences, University of Hawai`i at Manoa.
1998-2003: Assistant Professor, Dept. of Information and Computer Sciences, University of Hawai`i at Manoa.
1995-1998: Adjunct Faculty, Department of Information Science, University of Pittsburgh.
1992-1998: Research Associate, Learning Research and Development Center, University of Pittsburgh.

Selected Publications

Andriessen, J., Baker, M. & Suthers, D. (Eds., 2003), Arguing to Learn: Confronting Cognitions in Computer-Supported Collaborative Learning Environments. Dordrecht: Kluwer.

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Synergistic Activities

Hawai`i Networked Learning Communities (hnlc.org)
Dr. Suthers is founder and co-PI of Hawaii Networked Learning Communities (HNLC), a partnership of the Hawai`i Department of Education and the University of Hawai`i to improve science, mathematics and technology learning in K-12 rural schools. HNLC focuses on fostering an inquiry-driven, standards-oriented approach to classroom instruction, with a special emphasis on accessing Hawaii's rich ecological resources and cultural heritage to develop meaningful and relevant classroom projects and studies. Leadership development is supported through the use of

collaboration tools for teacher learning and an online resource database. HNLC is a Rural Systemic Initiative funded by the National Science Foundation. In the context of HNLC, Dr. Suthers directs the development and evaluation of hnlc.org, an interactive web site supporting a statewide community of educators.

Northwestern Hawaiian Islands Multi-Agency Education Project (hawaiianatolls.org)

Dr. Suthers is a member of a volunteer multi-agency collaboration focused on education and outreach pertaining to the ecological, cultural and scientific value of the Northwestern Hawaiian Islands (NWHI). He hosts the project's web site, hawaiianatolls.org, and collaborates with NOAA staff in its maintenance. Dr. Suthers also served as a science writer on NOAA's 2004 research expedition to the NWHI, maintaining web site reports of expedition activities via satellite connection, and was co-planner of a NOAA-sponsored teacher's expedition to the Northwestern Hawaiian Islands, both aboard the NOAA research vessel Hi`ialakai. Dr. Suthers also obtained local foundation funding (H.K.L. Castle) for dissemination of the Navigating Change curriculum (navigatingchange.org), which is based on the NWHI.

Course Development

Dr Suthers developed and added three courses to the ICS curriculum.

ICS 463 Introduction to Human Computer Interaction Design: An undergraduate introduction to the theory of HCI and practice of designing usable human-computer systems.

ICS 667 Advanced HCI Design Methods: Compares usability-engineering methodologies. Students develop and evaluate an interactive application of their own.

ICS 668 Technology Supported Collaboration and Online Communities: A review of current literature on the topic. Students also conduct an intensive review of a specialty of their choice, carry out a small empirical study, or design and evaluate a prototype application.

Service

Dr. Suthers is on the editorial boards for the International Journal of Computer Supported Collaborative Learning, Interactive Learning Environments, the Journal of the Learning Sciences, and Research and Practice in Technology Enhanced Education. Conference related service includes the following: Program Co-chair for Computer Supported Collaborative Learning 2005 and International Conference on Computers in Education 2003; Interactive Events chair for the Computer Supported Collaborative Learning Conference in 2002 (Boulder) and 2003 (Bergen); Co-chair of the Hawai'i International Conference on the System Sciences mini-track on "Roles and Issues of Computational Media in Learning Communities," 2000 and 2001; Workshop Program Chair at the Computer Supported Collaborative Learning (CSCL 2000) conference; and workshop chair for several workshops in the 1990s. He also regularly serves on program committees for conferences such as AIED, CHI, CSCL, HICSS, ICLS.

Awards and Recognition

Dr. Suthers received an NSF CAREER award in 2001. He was the keynote speaker at AIED 2003 and invited speaker at ICCE 2006.

Dr. Suthers and colleagues received the Center for Innovations in Learning Technologies (CILT) "Spotlight" award, Community Tools area, awarded at the annual American Education Research Association meeting in 2000.

Collaborators & Other Affiliations

Collaborators and Co-Editors within the past 48 months:

Jerry Andriessen (Utrecht), Michael Baker (CNRS & Université Lumière), Tak-Wai Chan (National Central University, Taiwan), Yam San Chee (National University of Singapore), Andy Collins (NOAA), Angeles Constantino (ITESM), Sharon Derry (U. Wisconsin), Violet Harada (U. Hawai'i), Friedrich Hesse (Knowledge Media Research Center, Germany), Cindy Hmelo (Rutgers), Chris Hundhausen (Washington State University), Vicki Kajioka (Hawai`i DOE), Tim Koschmann (Indiana University), Nancy Law (Hong Kong University), Alan Lesgold (U. Pittsburgh), Mary Marlino (DLESE), Naomi Miyake (Chukyo University, Japan), Ann Renninger (Swarthmore), Wes Shumar (Drexel), Gerry Stahl (Drexel), Eva Toth (CMU), Steve Weimar (Math Forum).

Graduate and Postdoctoral Advisors:

Dissertation: Victor Lessor, Edwina Rissland, Klaus Schultz (deceased), and Beverly Woolf (University of Massachusetts). As research associate: Alan Lesgold (University of Pittsburgh).

Thesis Advisor and Postgraduate Scholar Sponsor:

Ph.D. Thesis awarded: Angeles Constantino (ITESM, Monterrey Mexico). Master's Thesis awarded: David Burger, Wil Doane, Bruce Harris, Bo Yang (University of Hawai'i). Postdoctoral sponsor: Christopher Hundhausen (formerly University of Hawai`i). Primary advisor for 5 awarded degrees and 9 students in progress. Served on numerous other committees.

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Professional Preparation

SUNY Stony Brook, Educational Computing	M.S. 1985
Vanderbilt University, Psychology and Human Development	M.S. 1982
Vanderbilt University, Cognitive Studies	Ph.D. 1991

Appointments

Associate Professor of Educational Psychology	2004-present
Assistant Professor of Educational Psychology Graduate School of Education Rutgers, The State University of New Jersey	1998-2004
Research Associate, Learning Research and Development Center University of Pittsburgh	1996-1998
Project Manager, Multiple Case-based Approach to Generative Environments for Learning Georgia Institute of Technology	1995- 1996

Five Relevant Publications

Hmelo-Silver, C. E., Marathe, S., & Liu, L. (in press). Fish swim, rocks sit, and lungs breathe: Expert-novice understanding of complex systems. *Journal of the Learning Sciences.*

Hmelo-Silver, C. E. (2006). Design principles for scaffolding technology-based inquiry. In A. M. O'Donnell, C. E. Hmelo-Silver, & G. Erkens (Eds.). *Collaborative learning, reasoning, and technology* (pp. 147-170). Mahwah, NJ. Erlbaum.

Derry, S. J., Hmelo-Silver, C. E., Nagarajan, A., Chernobilsky, E., & Beitzel, B. (2006). Cognitive Transfer Revisited: Can We Exploit New Media to Solve Old Problems on a Large Scale? *Journal of Educational Computing Research, 35,* 145-162.

Hmelo-Silver, C. E., & Chernobilsky, E. (2004). Understanding collaborative activity systems: The relation of tools and discourse in mediating learning. In Y. B. Kafai, W. A. Sandoval, N. Enyedy, A. S. Nixon & F. Herrera (Eds.), *Proceedings of Sixth International Conference of the Learning Sciences* (pp. 254-261). Mahwah NJ: Erlbaum.

Hmelo-Silver, C. E. (2003). Analyzing collaborative knowledge construction: Multiple methods for integrated understanding. *Computers and Education, 41,* 397-420

Five Significant Publications

Hmelo-Silver, C.E., Katic, E., Nagarajan, A., & Chernobilsky, E. (in press). Soft leaders, hard artifacts, and the groups we rarely see: Using video to understand peer learning processes. To appear in R. Goldman, R. Pea, B. Barron, & S. Derry (Eds.), *Video research in the learning sciences*. Mahwah NJ: Erlbaum.

Hmelo-Silver, C. E., Chernobilsky, E., & Mastov, O. (2006). Representations for analyzing tool-mediated collaborative learning. In S. A. Barab, K. E. Hay, & D. T. Hickey (Eds.). *Proceedings of 7th International Conference of the Learning Sciences* (pp. 1059-1060). Mahwah. NJ: Erlbaum.

Hmelo, Silver, C. E. & Azevedo, R. (2006). Understanding complex systems: Some core challenges. *Journal of the Learning Sciences, 15,* 53-61.

Hmelo-Silver, C. E. & Pfeffer, M. G. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science*, *28,* 127-138.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn*?* *Educational Psychology Review, 16*, 235-266.

Synergistic Activities: (1) As part of NSF early CAREER award, I am using SBF representation to study expert-novice differences in understanding complex systems and using SBF as a conceptual representation to design instruction (2) As co-PI with Sharon Derry, developing technology online problem-based learning and methodology to study collaboration (3) co-PI on SLC catalyst grant to survey state of the art of research on complex causal learning, (4) co-chair, 2007 Computer–supported Collaborative Learning Conference (5) co-PI on NSF ALT project that is developing structure-behavior function modeling tool to help middle school students learn about aquaria.

Collaborators (over last 48 months): Jeff Charney (Rutgers). Ellina Chernobilsky (Rutgers), Clark Chinn (Rutgers), Sharon Derry (U. Wisconsin-Madison), Gijsbert Erkens (Utrecht), Ashok Goel (Georgia Tech) Teresa Hubscher-Younger (RPI), Rebecca Jordan (Rutgers), Elvira Katic (Rutgers), Hari Narayanan (Auburn), Marty Nemeroff (Rutgers), Lenore Neigeborn (Rutgers), Angela O'Donnell (Rutgers), Sadhana Puntambekar (U. Wisconsin- Madison), Spencer Rugaber (Georgia Tech), William Sofer (Rutgers).

Graduate Advisor: Prof. John Bransford, School of Education, University of Washington. Prof. Laura Novick, Vanderbilt University, Prof. Thomas Liao, SUNY Stony Brook

Current Graduate Students: Andrea DiMarco, Lei Liu, Surabhi Marathe, Lynne Richard, Suparna Sinha, Gwen Tanner

Graduates: Anandi Nagarajan

Gerry Stahl

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Drexel University
Philadelphia, PA 19104

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215-895-2494 (fax)
gerry.stahl@drexel.edu
www.cis.drexel.edu/faculty/gerry

Gerry Stahl teaches, publishes and conducts research in human-computer interaction (HCI) and computer-supported collaborative learning (CSCL). His new book, *Group Cognition: Computer Support for Building Collaborative Knowledge* is published by MIT Press. He is founding Executive Editor of the *International Journal of Computer-Supported Collaborative Learning* (ijCSCL). He is the Principal Investigator of the *Virtual Math Teams Project*, a large 5-year research effort in collaboration with the Math Forum@Drexel. He served as Program Chair for the international CSCL '02 conference and Workshops Chair for CSCL '03, CSCL '05, ICCE '06 and CSCL'07. He teaches undergraduate, masters and PhD courses in HCI, CSCW and CSCL at the I-School of Drexel.

Professional Preparation

Massachusetts Institute of Technology (MIT)	Humanities & Science (Math & Philosophy)	BS 1967
University of Heidelberg	Continental Philosophy	1967-68
University of Frankfurt	Social Theory	1971-73
Northwestern University	Philosophy	MA 1971
Northwestern University	Philosophy	PhD 1975
University of Colorado	Computer Science	MS 1990
University of Colorado	Computer Science	PhD 1993
University of Colorado	Computer Science & Cognitive Science	Postdoc 1996-99

Appointments & Professional Experience

2002-present **Associate Professor**
College of Information Science & Technology
Drexel University, Philadelphia, PA

2001-2002 **Visiting Research Scientist**
BSCW Development Team, CSCW Department, FIT
GMD and Fraunhofer Institutes, Bonn, Germany

1999-2001 **Assistant Research Professor**
Department of Computer Science & Institute of Cognitive Science
University of Colorado, Boulder, CO

1996-1999 **Post Doctoral Research Fellow**
Center for LifeLong Learning and Design
University of Colorado, Boulder, CO

1993-1996 **Director of Software R&D**
Owen Research Inc., Boulder, CO

Relevant Publications

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press. Available online at http://www.cis.drexel.edu/faculty/gerry/mit/.

Stahl, G. & Hesse, F. (2006). Inaugural issue. *International Journal of Computer-Supported Collaborative Learning (ijCSCL), 1* (1). Available online at http://ijCSCL.org.

Stahl, G. (Ed.). (2002). *Computer support for collaborative learning: Foundations for a CSCL community*. Proceedings of CSCL 2002. January 7-11. Boulder, Colorado, USA. Hillsdale, NJ: Lawrence Erlbaum Associates Available online at http://isls.org/cscl/cscl2002proceedings.pdf.

Stahl, G. (2005). *Groups, group cognition & groupware [keynote]*. Paper presented at the International Workshop on Groupware (CRIWG 2005), Racife, Brazil. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/criwg2005.pdf.

Stahl, G. (2003). *The future of computer support for learning: An American/German DeLFIc vision [keynote]*. Paper presented at the First Conference on e-Learning of the German Computer Science Society (DeLFI 2003), Munich, Germany. Proceedings pp. 13-16. Available online at http://www.cis.drexel.edu/faculty/gerry/publications/presentations/delfi.

Stahl, G. (2006). Analyzing and designing the group cognitive experience. *International Journal of Cooperative Information Systems (IJCIS)*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/ijcis.pdf.

Stahl, G. (2006). Group cognition in an online chat community: Analyzing collaborative use of a cognitive tool. *Journal of Educational Computing Research (JECR) special issue on Cognitive tools for collaborative communities*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/jecr.pdf.

Stahl, G. (2006). Sustaining group cognition in a Math chat environment. *Research and Practice in Technology Enhanced Learning (RPTEL), 1* (2). Available online at http://www.cis.drexel.edu/faculty/gerry/pub/rptel.pdf.

Stahl, G., Rohde, M., & Wulf, V. (2006). Introduction: Computer support for learning communities. *Behavior and Information Technology (BIT)*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/bit_intro.pdf.

Stahl, G. (2005). Group cognition in computer assisted learning. *Journal of Computer Assisted Learning*. Available online at http://www.cis.drexel.edu/faculty/gerry/publications/journals/JCAL.pdf.

Synergistic Activities

- 2005-2007: "*SLC Catalyst: Engaged Learning in Online Communities*." (PI with co_PIs Sharon Derry, Mary Marlino, K. Ann Renninger, Daniel Suthers, Stephen Weimar) $180,762; sponsor: NSF SLC.
- 2003-2008: "*IERI: Catalyzing & Nurturing Online Workgroups to Power Virtual Learning Communities.*" (PI with co-PIs Stephen Weimar and Wesley Shumar) $2,300,000; sponsor: NSF IERI.
- 2003-2005: "*Collaboration Services for the Math Forum Digital Library*" (PI with co-PIs Stephen Weimar and Wesley Shumar) $450,000; sponsor: NSF NSDL.
- 1997-2000: "*Allowing Learners to be Articulate: Incorporating Automated Text Evaluation into Collaborative Software Environments*" (primary author and primary software developer; PIs: Gerhard Fischer, Walter Kintsch and Thomas Landauer) $678,239; sponsor: James S. McDonnell Foundation.
- 1997-2000: "*Conceptual Frameworks and Computational Support for Organizational Memories and Organizational Learning*" (co-PI with Gerhard Fischer and Jonathan Ostwald), $725,000; sponsor: NSF.
- 1998-1999: "*Collaborative Web-Based Tools for Learning to Integrate Scientific Results into Social Policy*" (co-PI with Ray Habermann) $89,338;sponsor: NSF.

Collaborators & Other Affiliations

Scientific Advisory Boards: Knowledge Media Research Center (KMRC, Germany), Learning Sciences Laboratory (LSL, NIE, Singapore), Knowledge Practices Laboratory (K-P Lab, Finland).

Collaborators and Co-Editors: Clarence Skip Ellis, Gerhard Fischer, Raymond Habermann, Walter Kintsch, Thomas Landauer, Curtis LeBaron, Raymond McCall, Jonathan Ostwald, Alexander Repenning, Tamara Sumner (U. Colorado, Boulder); Robert Allen, K. Ann Renninger, Wesley Shumar, Stephen Weimar, Alan Zemel (Drexel U., Philadelphia); Timothy Koschman (Southern Illinois U.); Angela Carell, Thomas Herrmann, Andrea Kienle, Ralf Klamma, Kai-Uwe Loser, Wolfgang Prinz, Markus Rohde, Volker Wulf (Germany); Sten Ludvigsen, Anders Morch, Barbara Wasson (Norway), Cesar Alberto Collazos (Chile); Jan-Willem Strijbos (Netherlands). Carolyn Rose (CMU), Daniel Suthers (Hawaii), Sharon Derry (Wisconsin), Mary Marlino (UCAR)

Dissertation Advisors: Gerhard Fischer, Clayton Lewis, Raymond McCall, Mark Gross (U. Colorado, Boulder). Samuel Todes, Theodor Kiesel (Northwestern).

Graduate Students, Post-Docs, Visiting Researchers: Rogerio dePaula, Elizabeth Lenell, Alena Sanusi, David Steinhart (U. Colorado, Boulder); Murat Cakir, Ilene Litz Goldman, Trish Grieb-Neff, Yolanda Jones, Wanda Kunkle. Deb LeBelle, Debra McGrath, Pete Miller, Johann Sarmiento, Ramon Toledo, Jim Waters, Alan Zemel, Nan Zhou (Drexel U., Philadelphia); Andrea Kienle (U. Dortmund, Germany); Cesar Alberto Collazos (U. Chile, Chile); Jan-Willem Strijbos (Open U., Netherlands); Fatos Xhafa (Open U. Catalonia, Spain); Stefan Trausan-Matu (Politechnica University of Bucharest, Romania); Angela Carell (Bochum U., Germany); Martin Wesner, Martin Műhlpfordt (FhG-IPSI, Germany); Elizabeth Charles (Canada), Weiquin Chen (Norway).

A more complete resume with live links is available at: http://www.cis.drexel.edu/faculty/gerry/resume.html

Stephen Andrew Weimar
Director of the Math Forum @ Drexel

Address: The Math Forum @ Drexel
3210 Cherry Street
Philadelphia, PA 19104
215-895-0236

PROFESSIONAL PREPARATION

Haverford College	Philosophy	B.A., 1980

APPOINTMENTS

Director, The Math Forum @ Drexel, Drexel University (2001-present): Responsible for research and business development, operations, and program design of the leading application of the Internet to improve mathematics education.

Vice President, Learning Partnerships, WebCT (2000-2001): Led the development of the online academic communities and consulting services to form an effective business unit driving the successful implementation of WebCT for higher education, K-12, and corporate clients.

Co-Principal Investigator and Project Director, Geometry Forum, Math Forum, Swarthmore College (1994–2000)**:** Coordinate project development for this Internet-based electronic community and NSF-sponsored research project in math education and telecommunications.

Education Consultant (1988–1994): Freelance consultant to schools, colleges, and educational organizations for teacher professional development.

Executive Director, Philadelphia Chapter of Educators for Social Responsibility (ESR) (1983–1988): Established and administered this professional organization for public, private, and parochial school teachers in the Philadelphia area.

Math Teacher, Germantown Friends School, Philadelphia (1980–1983): Middle and high school mathematics.

PUBLICATIONS

Weimar, S, A., et. al. (1993-2007). *The Math Forum* http://mathforum.org/

Giersch, S., Klotz, E. A., McMartin, F., Muramatsu, B., Renninger, K. A., Shumar, W., et al. (2004, July/August). If you build it, will they come? Participant involvement in digital libraries. *D-Lib Magazine, 10*(7/8). Retrieve from http://www.dlib.org/dlib/july04/giersch/07giersch.html

Renninger, K. A., Weimar, S. A., & Klotz, E. A. (1998) Teachers And Students Investigating And Communicating About Geometry: The Math Forum. In R. Lehrer and D. Chazan (Eds.), *New Directions in Teaching and Learning Geometry*. Hillsdale, NJ: Lawrence Erlbaum Associates.

SYNERGISTIC ACTIVITIES

Co-Principal Investigator, *Leadership Development for Technology Integration,* creating online workshops and site-based leadership development that drive the use and integration of math software tools from the National Science Digital Library (NSDL).

Co-Principal Investigator, *Customized Resources for NSDL*, a collaboration with Beverly Woolf at the University of Massachusetts to provide instructional middleware that will solicit teacher/student input about learning needs and characteristics, personalize instruction for individual an student, based on cognitive, affective and social characteristics, and grade the effectiveness of the resource.

Co-Principal Investigator, Virtual Math Teams, a collaboration with Gerry Stahl in the Drexel College of Information Science and Technology investigating effective environments for online mathematics problem-solving in groups. A key goal is to develop scalable systems to support student participation in and learning from the Problem of the Week.

Co-Principal Investigator, Web Math Communication, a collaboration with Krandick and others in the Drexel Department of Computer Science investigating strategies for improving students' and mentors' reuse of prior questions and answers, along with tools to enhance mathematical communication and exploration.

COLLABORATORS & OTHER AFFILIATIONS

Agogino, Alice, U. Cal. Berkeley
Albers, Donald, Math. Assoc. of America
Awerbuch, Jonathan, Drexel University
Char, Bruce, Drexel University
Chung, Mark, SRI
Croft, Bruce, UMass
Cuoco, Al, EDC
Derry, Sharon, University of Wisconsin
DiGiano, Christopher J., SRI
Duffin, Joel, Utah State
Falk, John, Institute for Learning Innovation
Goldenberg, Paul, EDC
Heal, Robert, Utah State
Hewett, Thomas, Drexel University
Hoadley, Chris, Penn State
Johnson, Jeremy, Drexel University
King, Jim, Washington
Krandick, Werner, Drexel University
Loken, Eric, Penn State
Marlino, Mary, DLESE
Merlino, Joe, LaSalle College
Moore, Lang, Duke University
Panoff, Robert, Shodor
Reese, George, University of Illinois, Urbana-Champaign
Renninger, K. Ann, Swarthmore College
Repenning, Alex, University of Colorado, Boulder
Roschelle, Jeremy, SRI
Shechtman, Nikki, SRI
Shumar, Wesley, Drexel University
Simutis, Len (Eisenhower National Clearinghouse)
Stahl, Gerry, Drexel University
Suthers, Daniel, University of Hawaii
Underwood, Jody, ETS
Webb, Norman L., U. of Wisconsin
Wood, Bill, U. of Maryland
Woolf, Beverly, University of Massachusetts

Alan R. Zemel

Department of Culture & Communication
Drexel University
Philadelphia, PA 19104

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215-895-1533 (fax)
arz26@drexel.edu

Alan R. Zemel teaches, publishes and conducts research in language and social interaction (LSI) and computer-supported collaborative learning (CSCL). He has worked as a post-doc on the Deixis Project at the Southern Illinois University School of Medicine and the *Virtual Math Teams Project*, a large 5-year research effort in collaboration with the Math Forum@Drexel.

Professional Preparation

University of Pennsylvania	Regional Science and Economics	BA 1976
University of Pennsylvania	Regional Science	MA 1976
Temple University	Rhetoric and Communication	PhD 2002
Southern Illinois University School of Medicine	Medical Education	Postdoc 2002-04
Drexel University	College of Information Science & Technology	Postdoc 2004-06

Appointments & Professional Experience

2006-present **Auxilliary Instructor**
Department of Culture & Communication
Drexel University, Philadelphia, PA

2004-2006 **Research Manager**
College of Information Science & Technology
Drexel University, Philadelphia, PA

2002-2004 **Post Doctoral Research Fellow**
Department of Medical Education
Southern Illinois University School of Medicine, Springfield, IL

2000-2002 **Instructor**
Department of Communication
Ursinus College, Collegeville, PA

Relevant Publications

Koschmann, T., Stahl, G., Zemel. A. (2007) "The Video Analyst's Manifesto (or The Implications of Garfinkel's Policies for Studying Practice within Design-Based Research)" In R. Goldman, B. Barron, S. Derry, & R. Pea (Eds.), *Video research in the learning sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Zemel, A., Xhafa, F., Stahl, G. (2005). Analyzing the Organization of Collaborative Math Problem-Solving in Online Chats Using Statistics and Conversation Analysis. *Lecture Notes in Computer Science*, Volume 3706, Pages 271 – 283.

Koschmann, T., Zemel, A., Conlee-Stevens, M., Young, N., Robbs, J., and Barnhart, A. (2005) How *do* people learn: Member methods and communicative mediation. In R.Bromme, F. Hesse, & H. Spada (eds.) *Barriers and biases in computer-mediated knowledge communication (and how they may be overcome).* Amsterdam: Kluwer Academic Press.

Koschmann, T., Zemel, A., Conlee-Stevens, M., Young, N., Robbs, J., and Barnhart, A. (2003) "Problematizing the problem: A single case analysis in a dPBL meeting." In B. Wasson, S. Ludvigsen & U. Hoppe (eds.) Designing for change, 37-46. Amsterdam: Kluwer Academic Press.

Pomerantz, A. and Zemel, A. (2003). "Perspectives in interviewers' queries." In Harry van den Berg et al. (eds.) *Analyzing Interviews on Racial Issues*. Cambridge: Cambridge University Press.

Conference Presentations

Zemel, A., Shumar, W., Cakir, M. (2006) *The disembodied act: Copresence and indexical symmetry in computer-mediated communication.* Paper prepared for presentation CSCL 2007, New Brunswick, NJ.

Zemel, A., Xhafa, F., & Stahl, G. (2005). *Analyzing the organization of collaborative math problem-solving in online chats using statistics and conversation analysis.* Paper presented at the CRIWG International Workshop on Groupware, Racife, Brazil.

Zemel, A., Xhafa, F., & Cakir, M. (2005). *What's in the mix? Combining coding and conversation analysis to investigate chat-based problem-solving.* Paper presented at the 11th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI 2005), Nicosia, Cyprus.

Zemel, A., & Koschmann, T. (2005). *Understanding-as-participation: A single case analysis of a problem-based learning meeting.* Paper presented at the International Institute for Ethnomethodology and Conversation Analysis Conference (IIEMCA 2005), Waltham, MA.

Zemel, A. (2005). *Texts-in-interaction: Collaborative problem-solving in quasi-synchronous computer-mediated communication.* Paper presented at the International Conference of Computer-Supported Collaborative Learning (CSCL 05), Taipei, Taiwan.

Collaborators & Other Affiliations

Collaborators: Chuck Goodwin (UCLA), Curtis LeBaron (Brighan Young University), Wesley Shumar, Gerry Stahl, Stephen Weimar, (Drexel U., Philadelphia); Timothy Koschman (Southern Illinois U.); Anita Pomerantz (SUNY Albany), Garry Dunnington (Southern Illinois U.), Murat Cakir, Ramon Toledo, Nan Zhou (Drexel U., Philadelphia); Fatos Xhafa (Open U. Catalonia, Spain); Stefan Trausan-Matu (Politechnica University of Bucharest, Romania); Martin Wesner, Martin Műhlpfordt (FhG-IPSI, Germany); Elizabeth Charles (Canada).

Dissertation Advisors: Anita Pomerantz (SUNY Albany), Herb Simons, Joseph Schwartz (Temple University).

Letters of Support

Research Partners

Amy Bruckman, Associate Professor, Georgia Institute of Technology. *(Advisory Board.)*

Clark Chinn, Associate Professor, Rutgers University.

Sharon Derry, Professor, University of Wisconsin-Madison. *(Advisory Board.)*

Noel Enyedy, Assistant Professor, University of California, Los Angeles.

Andreas Harrer, Faculty, Universitat Duisburg-Essen.

Jim Hewitt, Associate Professor, University of Toronto.

Tim Koschmann, Associate Professor, Southern Illinois University. *(Advisory Board.)*

Angela O'Donnell, Professor, Rutgers University.

Carolyn Rose, Research Scientist, Carnegie Mellon University.

Alan Zemel, Auxilliary Instructor, Drexel University.

Evaluator

Ann Renninger, Professor, Swarthmore College**.**

Georgia Tech College of Computing
Interactive & Intelligent Computing

January 29th, 2007

Prof. Daniel D. Suthers
Associate Professor
University of Hawai'i at Manoa
1680 East West Road, POST 309B
Honolulu, HI 96822

Dear Dan,

I'm fascinated to hear about your proposal "Representations for Analyzing Collaborative Knowledge Construction in Technology-Mediated Learning Environments." Computer Supported Collaborative Learning (CSCL) is a field of growing importance. Yet researchers in the field don't yet have a strong toolkit to truly understand collaborative discourse. This research project addresses a key need in the field, and I expect will be a strong contribution.

I would love to be involved in this effort, to the extent that my time allows. I look forward to hearing more as the project progresses, and would be happy to offer advice as appropriate. I'd also be interested in using the tools you create and giving you feedback on them. Best of luck with it--it's a timely and important endeavor.

Sincerely,

Amy Bruckman
Associate Professor
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332-0760

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THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Graduate School of Education • 10 Seminary Place • New Brunswick • New Jersey 08903

January 29, 2007

Dear Dan, Gerry, and Cindy:

Thank you for the invitation to be participate in your REESE proposal "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments." I have for many years been interested in how students construct knowledge during collaborative interactions, and I welcome the opportunity to participate in this project. In particular, my work has focused on developing alternative methods of representing argumentative discourse—an area that is of great interest to the CSCL community at present. I believe that this area is ripe for important innovations in representing discourse and in using these representations to promote knowledge building.

I look forward to participating in the planned datafests and other collaborative activities. As we share ideas at these events, we will be no doubt find many ways to improve current methods of representing discourse. I expect that we will also generate entirely new ideas for representing discourse as we consider strengths and weaknesses of current analyses and tools. I also look forward to collaborating toward the development of software tools to enable scholars to analyze discourse in more powerful ways.

I thank you again for the opportunity to collaborate in what promises to be a very important project.

Yours sincerely,

Clark A. Chinn
Director, Ph.D. Program in Education
Associate Professor, Department of Educational Psychology
Graduate School of Education
Rutgers University
10 Seminary Place
New Brunswick, NJ 08901

WCER
WISCONSIN CENTER FOR EDUCATION RESEARCH

January 29, 2007

Dr. Daniel D. Suthers
Department of Information and Computer Sciences
University of Hawaii at Manoa
Honolulu, HI 96822

Dear Dr. Suthers:

I am honored and excited that you have invited me to participate as a researcher and advisory board member in your project "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments," being submitted to NSF's REESE program. As you know, I have long been very interested in the problem of analyzing technology-mediated interactions in online collaborative learning environments, and I both conduct research and teach graduate courses on this topic. Two trends that make this research of vital importance at this time include the increasing global proliferation of virtual teamwork and the growing importance of formal and informal online communities as contexts for significant problem solving and learning. The research you propose is timely and important and has potential to strongly impact the future of learning and collaborative work on a global scale.

I am familiar with the methodological developments that you will be synthesizing and have the highest respect for the team that developed them. This project will have very broad impact and substantial intellectual merit and I accept with enthusiasm this opportunity to play a key role in it. I eagerly look forward to being a participant in the data analysis sessions you describe as well as an active member of your advisory team.

Sincerely,

Sharon J. Derry
Professor
Educational Psychology

UNIVERSITY OF CALIFORNIA, LOS ANGELES

UCLA

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

Graduate School of Education & Information Studies
P.O. Box 951521
Los Angeles, CA 90095-1521

Dear NSF REESE,

I am writing this letter to express my enthusiastic support for the proposed project titled, "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments." Having participated in related 'datafests' I would jump at the chance to participate in the proposed activities.

My program of research investigates how people learn specific disciplinary concepts and practices through social interaction and instructional conversations. In most of my studies I employ labor intensive, micro-analytic video analysis methods to study face-to-face conversations that occur while groups of students are using innovative learning technologies designed by myself or by other researchers. Within this broad area of inquiry, my research rests on three pillars. First, all of my studies aim to enumerate and elaborate on the elements of a classroom culture—the practices, values, participation structures, and norms—that contribute to the effectiveness of it as a learning environment. Second, my studies (and my instructional designs) are constructed to help the field better understand how the design and use of external representations such as graphs, diagrams, and maps spark, support, and anchor productive learning conversations. Third, my recent research examines the connections between academic, classroom conversations and everyday, out of school discourse practices, and how they can be leveraged to create learning opportunities for urban students from non-dominant cultural groups and linguistic minorities.

The proposed project fills an important need in the field of CSCL and in education in general—the development of new methods for studying naturalistic data of learning that draw on the strengths of interactional and conversational analysis but streamlining them so that they can be applied more broadly and systematically. The development of new computer tools for this analysis is an important contribution of the proposed research, and one that the PIs of the project (Hmelo-Silver, Stahl and Suthers) are well qualified to deliver.

Early in my career I had the pleasure of attending a similar event to the one proposed in this project, an invitational 'datafest' organized by Timothy Koschmann. Participating in this datafest was the most productive conference I have attended to date and as a junior scholar was instrumental in shaping my methods and my program of research. What makes the proposed datafest more promising than one I attended previously is the tight analytic focus on issues of computer supported collaborative learning. Bringing a group of scholars together that share a track record on studying learning in computer-mediated settings and that share a commitment to a trying out a new set of analytic tools on the persistent problems of studying that context has the potential to shape the field and greatly increase its impact on the larger field of education and improving the learning opportunities for students.

Sincerely,

Noel Enyedy
Assistant Professor
UCLA Graduate School of Education & Information Studies

UNIVERSITÄT
DUISBURG
ESSEN

Faculty of Engineering
Department of Computer Science and
Applied Cognitive Science

Dr. rer. nat. Andreas Harrer

Universität Duisburg-Essen ● 47057 Duisburg

Telephone +49 (203) 379 – 3554

Fax +49 (203) 379 – 3557

E-Mail harrer@informatik.uni-duisburg.de

Office Lotharstr. 65, LF Raum 127

Date January, 26th, 2007

Letter of support for proposal “Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments”

Dear members of the REESE evaluation board,

As the leader of an European research initiative on collaboration analysis, I am writing you to give my strong support to the project proposal of Daniel Suthers, Cindy Hmelo-Silver, and Gerry Stahl.

With a background in Intelligent Tutoring Systems and Computer-Supported Collaborative Learning, I have worked in the field of collaboration analysis for several years. Our group's results of analysis on synchronous shared workspaces and asynchronous discussion forums have been published internationally (CSCL conferences 2003, 2005 and journal of web-based communities 2006). This research is supported currently by a European reasearch team “Computer-based Analysis and Visualization of Collaborative Learning Activities (CAViCoLA)” within the European-funded Network of Excellence “Kaleidoscope”. I am the leader of this research initiative between four European project partners (based in Germany, Spain, and Greece).

The research conducted in that initiative is oriented towards Analysis, Representation, and Visualisation of collaborative learning in different settings (synchronous, asynchronous, and blended scenarios). Among the issues of interest are social networks, dynamic roles, and temporal aspects of interactions. Thus I see a vast potential for synergy between the grant proposal “Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments” and our CAViCoLA project: On the one hand the coordination of software development using interoperable protocols and formats is highly desirable, on the other hand by utilization of this interoperability practical joint analysis of captured data becomes feasible.The activities of the CAViCoLA team are currently funded until end of 2007 (as the whole Kaleidoscope project) and will be followed up by grant proposals this year, so that we assume a longer lasting cooperation with this proposal can be established using the synergies of both consortia.

Kind regards,

Andreas Harrer

OISE UT
ONTARIO INSTITUTE FOR STUDIES IN EDUCATION OF THE UNIVERSITY OF TORONTO

January 28, 2007

Dr. Jim Hewitt
Associate Professor,
Ontario Institute for Studies in Education,
University of Toronto,
Toronto, Canada.

Dear Review Committee:

Please accept this letter as an indication of my strong support for the research proposal, "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments" submitted to the NSF REESE program by Drs. Cindy Hmelo-Silver, Gerry Stahl and Daniel Suthers. The Principal Investigators are key researchers in the field of Computer Supported Collaborative Learning (CSCL) and their proposal reflects an urgent need to develop better instrumentation to support CSCL analyses. Given their considerable collective experience (in particular, Dr. Suthers' dependency graph/uptake analysis, Dr. Hmelo-Silver's timeline-based visualization, and Dr. Stahl's expertise in group cognition), I feel they are well positioned to make important advances in this area.

Much of my enthusiasm for the proposed research is due to its potential to contribute to, and extend, my own explorations of online discourse and knowledge building. In recent years, I have examined how discussion threads in distance education courses develop over time, and the various social and technological factors that can support, impede, or subtly undermine collaborative discourse. Research suggests that traditional threaded computer conferencing software lacks critical supports for knowledge building and promotes diverging, add-on style interaction rather than the more sophisticated operations (such as synthesis and superordination) required for sustained, progressive knowledge work. An initiative to develop new methods of analyzing online collaboration would be of tremendous benefit to researchers, instructors and students alike, and would ultimately drive the design of learning environments that are more conducive to collaboration.

In recent years, I have compiled a large corpus of data extracted from over 50 graduate-level distance education computer conferencing courses. Using this dataset, I have explored how different types of online behaviors correlate with measures of student interactivity. Through this process, I have developed several metrics, which may be of use to the Principal Investigators. It is my hope that I can share some of this work with the broader community of CSCL researchers at the datafest events described in the research proposal. In my experience, events such as these are often the birthplace of new ideas and new collaborations that can lift the entire field.

I believe this is a very important project. Thank you for your consideration of this letter of support.

Sincerely,

Jim Hewitt

Jim Hewitt.

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January 27, 2007

Daniel Suthers, PhD
Dept. of Information & Computer Science
Univ. of Hawaii at Manoa
1680 East West Rd., POST 309B
Honolulu, HI 96822

Dear Dan,

Thank you for your invitation to play a role in your proposed project, "Representations for Analyzing Collaborative Knowledge Construction in Technology-Mediated Learning Environment." I have been interested for many years in the practices by which participants in interaction build understandings together. I have studied these practices primarily in face-to-face situations (classrooms, tutorial meetings, workplace settings). Trying to document such practices in technology-mediated environments is a logical next step.

I would be very happy to be a part of your project, both as a data session participant and as a member of your board of advisors.

Yours sincerely,

Timothy Koschmann
Associate Professor

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Department of Educational Psychology • Graduate School of Education
Rutgers, The State University of New Jersey
10 Seminary Place • New Brunswick • New Jersey 08901-1183

Dr. Cindy Hmelo-Silver,
Department of Educational Psychology,
Graduate School of Education,
10 Seminary Place,
New Brunswick, NJ 08901-1183

January 29th, 2007

Dear Cindy,

I am delighted to provide a letter of support for your grant *Representations for Visualizing Collaborative Knowledge Construction in Technology-Mediated Environments.* The proposal to improve methods for analysis of mediated interaction is timely and important. Many STEM disciplines rely on collaborative learning by students as part of their instructional programs. A meta-analysis of group learning in college courses in STEM disciplines provided evidence that such collaborative strategies were effective. However, methodologies for capturing why such groups are effective are still underdeveloped. Your proposal to advance the available analytic methods and tools will contribute to the advancement of effective instructional practices.

I am an expert in cooperative and collaborative learning. I have published two edited books in this area, *Cognitive perspectives on peer learning* and *Collaborative learning, reasoning, and technology.* I believe that I would make strong contributions to your work.

Sincerely,

Angela O'Donnell

Angela O'Donnell, Ph.D.
Professor of Educational Psychology

Carnegie Mellon

Language Technologies Institute &
Human-Computer Interaction Institute
School of Computer Science
Carnegie Mellon University
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Fax: (412) 268-1266

Dear Dan, Cindy, and Gerry,

I am writing this letter in very enthusiastic support of your NSF-REESE proposal entitled "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments". You certainly seem to be a team well positioned to attack this very important problem.

As you know, after completing my PhD in computational linguistics specializing in the area of robust natural language interpretation, I have been working for the past decade in the area of tutorial dialogue systems, and in recent years have been working in the area of computer supported collaborative learning. My involvement in the CSCL community started with work on the NSF funded TagHelper Tools project (http://www.cs.cmu.edu/~cprose/TagHelper.html). TagHelper tools supports semi-automatic collaborative learning process analysis as well as fully-automatic on-line filtering of collaborative learning conversations as they unfold. In the past year my group has completed two very successful small studies in which we have used this technology to trigger adaptive support for collaborative learning through dialogue agent technology. In both studies, the adaptive support lead to significant improvements in student learning.

Thank you for inviting me to participate in one of your analysis workshops. I will be very happy to join in with you to discuss how we can synthesize the wide range of work that has been done in the area of collaborative learning process analysis, and just as importantly to integrate the existing toolsets that each seem to specialize in only part of the problem. By integrating these various technologies, I think we can build an analysis tool set that will really have an impact on this important area of CSCL research. Specifically, I have a wide range of corpora from studies of computer supported collaborative learning that I would like to bring with me to this workshop as well as my own analysis toolkit, namely the NSF funded TagHelper tools. Beyond just participating in one workshop, I would really like to join forces with you in your long term vision to do this work, which synergizes very well with my own research agenda.

Best Wishes,

Carolyn P. Rosé

Carolyn Penstein Rosé

Drexel
UNIVERSITY
Department of Culture and Communication
Anthropology, Communication, Sociology

Dr. Gerry Stahl
College of Information Science and Technology
Drexel University
3141 Chestnut St.
Philadelphia, PA 19104

Dear Gerry,

I enthusiastically support your proposal, "Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments," to investigate the ways that learning occurs in technology-mediated settings. This is a natural and necessary extension of some of the exciting research you and I have been conducting in the VMT project. Prior to joining the VMT project, I was at SIU School of Medicine where Dr. Tim Koschmann and I were involved in developing a corpus of video recordings of surgical education in the operating room, as well as the analysis of a corpus of video recordings of problem-based learning sessions and distance learning in medical education.

This work is incredibly important, especially given the prevalence of computer-mediated forms of communication and distance learning in current educational environments. Even though computer- and technology-mediated forms of interaction are currently in use, work to understand how participants organize their online interactions to achieve educational outcomes is in its infancy. As a conversation analyst, I have been able to apply the analytical methodology of my discipline to transcripts of online interactions in the VMT project. We are now beginning to produce published results on the interactional organization of these chats and have begun to see how collaboration, learning and mathematics are constituted and achieved in these environments.

I am thrilled to be part of the project you are proposing. I would be happy to participate in datafests and collaborate in the analysis of learning and knowledge building that makes use of CSCL technologies. You have assembled an exceptional team of scholars and I know this project will yield outstanding insights. I applaud this ground-breaking work and hope that it is fully funded.

Alan Zemel
Auxilliary Instructor
Department of Culture and Communication

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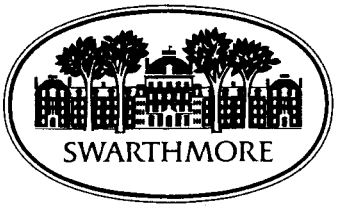

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1/28/07
Daniel Suthers
Department of Information and Computer Sciences
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1680 East West Road
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Honolulu, HI 96822

Dear Dan:

I would be pleased to be the external evaluator for your proposed REESE collaboration to study *Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments* with Cynthia Hmleo-Silver and Gerry Stahl. Understanding how learning knowledge building takes place through collaborative interaction in technology-enabled settings and how this can inform design is essential information for the learning sciences.

Trained in developmental psychology, with a background in teaching, my research and prior responsibilities as an evaluator have focused on the learning and motivation/participation of participants in the online environment. I have conducted evaluation research for the different iterations of the Math Forum@Drexel since its beginnings in 1992. I am familiar with the use of technology as a resource and tool for learning, and I have worked on services specifically designed to enhance interaction and knowledge building (e.g. the Math Forum's Ask Dr. Math and the Problems of the Week environment) as well as on projects that have included collaborations among multiple levels of learners with different roles and goals (e.g. the NSF-sponsored TRAILS and BRAP projects).

I am interested in the goals of the proposed project. There is much that archiving and being able to study collaborative interactions online offers—and, coordinating efforts across projects should allow identification of principles and the refinement of tools that can serve the design purposes of many.

I look forward to participating in the planned datafests, as well as reviewing materials and writing the summative evaluation. Thank you for inviting me to participate.

Sincerely,

K. Ann Renninger, Professor
Swarthmore College

K. ANN RENNINGER, Ph. D.

a. Professional Preparation

• Educational Testing Service, Developmental Psychology, Post-doctoral Fellow, 1985-6
• Bryn Mawr College, Education and Child Development, Ph.D., 1983
• Bryn Mawr College, Education and Child Development, M.A., 1979
• University of Pennsylvania, B.A., 1973

b. Appointments

• 1980- present, Swarthmore College, Department of Educational Studies, Professor
• 1974-77, George School, teacher

c. Publications

i. Five publications related to the proposed project

Renninger, K. A. (2003). A three-phase evaluation strategy for evaluating educational impact. White paper, Developing an Educational Strategy for the Educational Impact of the National Science Digital Library. Retrieved from http://eduimpact.comm.nsdl.org/evalworkshop/_renninger.php

Renninger, K. A., & Farra, L. (2003). Mentor-participant exchange in the Ask Dr. Math service: Design and implementation considerations. In M. Mardis (Ed.), *Digital Libraries as Complement to K-12 Teaching and Learning* (pp. 159-173). ERIC Monograph Series.

Renninger, K.A., Farra, L., & Feldman-Riordan, C. (2000). The impact of The Math Forum's Problems of the Week on students' mathematical thinking. *Proceedings of ICLS 2000.* Mahwah, NJ: Erlbaum. (www.mathforum.org/articles/rennin2_2000.html)

Renninger, K. A., Ray, L.S., Luft, I., & Newton, E. L. (2006). A comprehension tool for mathematics?: The Math Forum@Drexel's Online Mentoring Guide. In Barab, S., Hay, K., & Hickey, D. (Eds.) Proceedings of the International Congress of the Learning Sciences, Erlbaum.

Renninger, K. A., Ray, L. S., Luft, I., & Newton, E. L. (2005). Coding online content-informed scaffolding of mathematical thinking. *New Ideas in Psychology*, 23, pp. 152-165.

ii. Five significant publications

Hidi, S. & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41 (2), 111-127.

Renninger, K.A. (1998). Developmental psychology and instruction: Issues from and for practice. In I.E. Sigel & K.A. Renninger (Vol. Eds.) *Child psychology in practice,* Volume 4. In W. Damon (Gen. Ed.), *Handbook of child psychology* (pp. 211-274), 5th edition. New York, NY: John Wiley and Sons.

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone and J. M. Harackiewicz (Eds.) *Intrinsic motivation: Controversies and new directions (pp. 373-404).* San Diego, CA: Academic Press.

Renninger, K. A. & Hidi, S. (2002). Interest and achievement: Developmental issues raised by a case study. In A. Wigfield & J. Eccles (Eds.), *Development of achievement motivation (pp. 173-195*). New York: Academic Press.

Renninger, K.A. & Shumar, W. (2002). Community building with and for teachers: *The Math Forum* as a resource for teacher professional development. In K.A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp 60-95). New York, NY: Cambridge University Press.

d. Synergistic Activities

- Consultant on interest and motivation, National Academies Board of Science, Learning in Informal Science Settings, 2006-7
- Co-PI, NSF Science of Learning Center Catalyst grant, *Engaged Learning in Online Communities,* 2005-2006.
- Evaluation, Flora and William Hewlett Foundation Grant to Swarthmore College, *The Role of Scientific Literacy in the Liberal Arts Curriculum*, 2001-2005.
- Evaluation, NSF Project: *Online Mentoring Grant* to The Math Forum at Drexel University, 2002-2004.
- Evaluation, NSF Project: *Training and Resources for Assembling Interactive Learning Systems (TRAILS)*, a collaboration of The Math Forum and SRI International, 2002-2005.
- Research and Evaluation, The Math Forum, 1992- present.
- Collaborative research with Swarthmore College students and teacher Mark Springer to study motivation and learning in a middle school classroom with an integrated curriculum (science, social studies, English), Radnor School District, 2002- present.
- Advisory Panel, NASA Explorer Schools Project, 2004-2006.
- Advisory Board, Syracuse University Science of Learning Center, *Engaging Learning in the 21st Century*, 2004-present.
- Participant, NSF Supported *Workshop on Cyber Learning* (Ed Lazowska and Roy Pea, Chairs), January 2005.
- Participant, Organizer, and Writer, NSF-sponsored *Participant Interaction in Digital Library Workshop*, Drexel University, February, 2004.
- Participant and contributor, NSF *NSDL Evaluation Workshop*, October , 2003.
- CILT Mini-Grant Recipient, with Shumar, Hoadley, Recker, & Schlager, May 2003.
- CILT Community Tools Workshop Coordinating Committee, 2002.
- Participant, *STEME-Lab Workshop* on supporting shared tools for NSDL research, February 2002
- Task Force on Web Methodology, *Association of Internet Researchers*, 2000-2003.
- Co-Editor, *Child Psychology and Practice* , in the *Handbook of Child Psychology* (Richard Lerner and William Damon, Gen Eds.), 1998, 2006.
- Editorial Board, *American Educational Research Journal*, *Applied Developmental Psychology;*
- Project and Grant Reviewer, Italian Ministry for Universities and Research, National Academy of Education, MIUR- COFIN, National Science Foundation, Spencer Foundation, SSHRC/CRSH.