

Fostering Peer Collaboration with Technology

Introduction

In this symposium we address recent developments in learning environments, including logging, data mining, authoring, and collaboration tools that have opened new doors for research. In particular we present projects that afford logging students' data in a very fine-grained way and data mining techniques to characterize students' learning beyond their mouse clicks. These systems have enhanced our ability to support students in collaboration while learning and well as track students' collaboration. Gobert's paper will discuss a collaborative learning study focused on collaborative model-building and peer critique which used the WISE infrastructure. Slotta's paper will present a new generation of a technological infrastructure, SAIL, which is based on WISE and logging from the Concord Consortium. The paper by Clarke and Dede will focus on data mining of rich data while students used the River City MUVE Environment. The paper by Gijlers et al will address the interaction between the tools used for inquiry and students' inquiry processes. Lastly, the paper by Koedinger will present methodologies, etc., developed by the Pittsburgh Science of Learning Center (PSLC) which support data collection and analysis in order to contribute to what we know about "robust learning".

Many of the papers will focus on data mining since it offers a potentially powerful analytic framework for many educational interventions that generate rich data sets and data-streams about student learning. For example, text mining analytics could aid in identifying patterns in the explanations and critiques of the two thousand students engaged in WISE model-based activities described in Gobert et al. Gijlers et al could conduct similar analyses on the text generated by their chat tool, looking for patterns related to argumentation, collaborative reasoning, and elaboration. The SAIL scalable architecture Slotta describes could provide a common framework for structuring the databases on which various researchers conduct data mining. The PSLC LearnLab testbed illustrates the type of venue that could generate the large amounts of data and substantial numbers of students for which data mining is particularly powerful and appropriate. In recognition of this, research using data mining is already taking place in the intelligent tutoring systems community.

Collectively, these projects represent advances to this area of research offering the following affordances: (1) *data collection*, such that they afford accurate capture of students' actions; (2) *authoring and customization*, which enables researchers to develop, and teachers to tailor curriculum materials that target research questions or student populations; (3) *tracking*, which allows materials and assessments to be accurately managed, versioned, etc.; (4) *integration*, which enables materials to be seamlessly incorporated into instruction; (5) *reach*, which enables researchers to conduct studies anywhere, collect data automatically, and easily make updates to materials for any school worldwide; and 6) *open source*, namely, that since many of these technologies are interoperable and open-source, dynamic development and rapid evolution are possible.

In this one and a half hour symposium, there will be a short introduction to the session followed by a presentation of each project. Dr. Dan Suthers will then serve as a discussant for the session. Dr. Suthers is presently Associate Professor in the department of Information and Computer Sciences at the University of Hawai'i at Manoa, where he directs the Laboratory for Interactive Learning Technologies (<http://lilt.ics.hawaii.edu>) and co-directs Hawai'i Networked Learning Communities (<http://hnlc.org>). His research is generally concerned with technology-supported collaborative learning and online learning communities, with applications to K-12, university and professional development contexts, making him an ideal discussant for this symposium. Dr. Suthers obtained his M.S. (1988) and Ph.D. (1993) degrees in Computer Science from the University of Massachusetts. Subsequently he worked at the Learning Research and Development Center of the University of Pittsburgh before coming to the University of Hawai'i.

Fostering collaborative model-building and peer critique on-line

Janice Gobert

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Model-based teaching and learning (Gobert & Buckley 2000) is an effective cognitive and pedagogical framework for scaffolding students' understanding of complex science domains such that the various components of the domain, i.e., the spatial, causal, and temporal features can be successfully integrated into rich mental models (Gobert, 2000). Peer collaboration has also been found to be a successful strategy for deepening and promoting students' knowledge building in many different disciplines (cf. Scardamalia & Bereiter, 1994; Gobert & Pallant, 2004). In this project, these two powerful pedagogical approaches are combined, namely model-building, and peer collaboration, in order to evaluate the efficacy for students' learning and characterize the affordances of this rich form of peer collaboration.

Two thousand middle and high school students from demographically diverse schools in California and Massachusetts collaborated on-line about plate tectonic activity in their respective location using WISE, Web-based Inquiry Science Environment (Linn, 1998). The curriculum engaged students in many inquiry-oriented, model-based activities which relied heavily on peer collaboration. For example, students were scaffolded in WISE as they: a) drew initial models of plate tectonic phenomena in their respective area using WISE; b) wrote explanations of their models and shared their models and explanations with students on the opposite coast (east vs. west); c) were scaffolded to critique their peers' models; d) revised their models based on this feedback; e) questioned their peers about plate tectonics on the opposite coast, and f) discussed the differences between E and W coast geology in an on-line forum. Previous analyses on this project have focussed on measuring content gains and epistemological gains for which significant gains were found for both (Gobert & Pallant, 2004). Additionally, analyses of a small subset of data illustrated the nature of model revisions which students made on the basis of their peers' critique. For this presentation, a deeper analyses of the students' model revisions, peer critiques, and peer questions will be presented in order to provide a context for understanding more deeply how peers can influence knowledge building and model revision.

Supporting Collaborative Inquiry: New Architectures, New Opportunities

James Slotta

University of Toronto

This paper will present recent progress in an open source technology framework that enables the development, exchange and interoperability of richly interactive learning materials. Building on ten years of success in the Web-based Inquiry Science Environment (WISE), but also responding to key limitations in the WISE technology architecture, Slotta and his colleagues have created a new Scalable Architecture for Interactive Learning (SAIL). SAIL enables the design and development of java-based learning content, with the goal of supporting an international open source exchange community. Departing from the server-client architecture of WISE, inquiry curriculum is distributed as a peer-to-peer network of local hosts that serve classrooms, schools and districts. Next-generation learning environments will be able to utilize the full functionality of student computers, benefiting from the strength of locally hosted networks and peer-to-peer functionality. Expanded functionality will emphasize Java-based modules that support a diversity of user experiences, including models and simulations such as those developed by other cognitive and educational researchers. For example, the European CoLab project will be integrated into a SAIL framework, allowing multi-user CoLab modules to be supported in a scaffolded learning environment similar to WISE. SAIL will enable a greater range of user interfaces (e.g., immersive game-like interfaces, menu driven interfaces, or distributed, hand-held interfaces) as well as a wealth of user functionality for synchronous design spaces, online communities for teachers and mentors, or language learners and multilingual communities.

The paper will present an overview of SAIL, then discuss its implications for (1) the delivery of innovations to a broad audience, (2) the easy collection of user data (e.g., work done by students) for purposes of feedback and assessment, (3) the promotion of content communities (e.g., an earth science curriculum community) and (4) the support of an open source developer community across

numerous projects that employ the SAIL architecture, leading to a greater dynamic evolution of our innovations, as well as interoperability across projects. Next, the paper will demonstrate a new wiki-based community for the learning sciences called the Community for Open Resource Exchange (CORE) that is currently supporting exchanges between numerous research labs. Finally, an early phase project will be demonstrated: the SAIL Smart Space: A configurable smart space capable of being shared as an open source research platform to enable studies of this important domain. SAIL Smart Space allows for the configuration of micro servers within a classroom, RFID nodes, and emphasizes curricular coherence across the following dimensions: physical space (i.e., within the 3 dimensions of the classroom, online, offline, at home, and on field trips); time (i.e., coordinating curriculum at all points of time and across numerous iterations); social context (i.e., supporting social groupings, jigsaws and exchanges); curricular space (i.e., various levels of variables, conditions, stages or other curricular phases). The paper will close with a discussion of the implications of open source research infrastructure for the learning sciences, particularly with respect to computer supported collaborative learning.

The River City MUVE

Jody Clarke, Chris Dede, Harvard University

As described in the National Research Council report, *Knowing What Students Know* (Pellegrino, Chudowsky & Glaser, 2001), sophisticated educational media now enable the collection of very rich datastreams about individual learners. For example, the River City MUVE has a customized ‘plug-in server’ that contains a data-tracking system. The data-tracking system allows us to collect, store, and retrieve information on the moment-by-moment movements, actions, and utterances of each student as they explore the River City MUVE environment. All items in the world that students can interact with have been tagged with identification codes. Every time a student clicks on a virtual object (picture, resident, sign, map, etc) or speaks to either a resident or teammate, the record is stored in a table in a relational database on the server. These data allow us to record the trajectory of each student as they work through the curriculum in the form of detailed log files—something that is not possible in traditional classroom practices. These log files provide extensive time-stamped records of where the students went in the world, what virtual objects they clicked on, who they talked to, and what they said.

We will share how we are using “data mining” techniques to make sense of our log file data and also present preliminary findings. “Data mining” is the process of selecting, exploring, and modeling large amounts of data to uncover previously unknown patterns (Gayle, 2000). The business world has been using this approach to identify patterns and behaviors of customers successfully for years (Gayle, 2000; Shaw, Subramaniam, Tan, Welge, 2001). Analyzing these rich datastreams of student participation using “data mining” can potentially yield formative, diagnostic feedback (Feng & Heffernan, 2005) and summative assessment (Hulshof, Wilhelm, Beishuizen, & Van Rijn, 2005) on student performance. It may also provide insights about complex patterns and dynamics of student behavior and learning (Ketelhut, Dede, Clarke, Nelson, & Bowman, in press) and collaborative problem solving and team learning processes (Avouris, Komis, Margaritis, & Fiotakis, 2004; Linton, Goodman, Gaimari, Zarrella, & Ross, 2003; Suthers & Hundhausen, 2003) that will be beneficial to the education community.

Interaction between tool and talk, how support for inquiry processes influences peer communication

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Various studies show that under specific conditions, collaboration can improve learning (Webb & Farrivar, 1999). This improvement depends strongly on the nature of peer interaction during collaboration (Webb, Nemer, & Zuniga, 2002). Elaborate responses and the extent to which students operate on the

contributions of their peers (level of transactivity) are associated with positive learning outcomes (Teasley, 1997; Webb et al., 2002). Recently, researchers have started to investigate the combination of collaborative learning and inquiry learning and designed scaffolds to support the collaborative inquiry learning processes (Bell, 2004; Gijlers & de Jong, 2005; Saab, Van Joolingen, & Van Hout-Wolters, 2005). Traditionally, tools designed to support collaboration aim at supporting the communication between group members. However, guidance directed at the *processes of inquiry*, may indirectly influence group communication as well as support student learning gains.

The results presented in this study are based on a re-analysis of data from two research projects. The main objective of the re-analysis is to examine the relation between nature and quality of students' communicative processes and the characteristics of the different task related scaffolds. In both projects, secondary school students (approximately 16 years) worked, in dyads, with a simulation environment within a physics domain (collisions or one dimensional kinematics) and communicated through a chat tool. Students' chat discussions as well as their inquiry learning activities were logged. During their interactions with the learning environment students were supported through one of the following tools: 1) a shared hypotheses scratchpad, that was designed to facilitate the collaborative construction of hypotheses, 2) a shared hypothesis table, that confronted students with differences in their individual opinions about specific propositions and 3) a concept mapping tool, that allowed students to collaboratively build a representation of the relations within the domain. All scaffolds focused on the process of generating and discussing hypotheses but differed on concrete vs. abstract and directive vs. restrictive dimensions.

The scheme used to code students' chat communication distinguishes different communicative acts including various forms of argumentation, collaborative reasoning, and elaboration. Analysis of the coded discourse focuses on the characteristics of the student chat discourse in relation to the similarities and differences between the scaffolds. The results of a preliminary analyses of students' interaction suggests that the characteristics of the different scaffolds not only affected students' inquiry learning processes but also affected their communication and argumentation processes, more specially the level of transactivity and consensus building process. For instance, it was found that the more restrictive tool (the shared hypothesis table) resulted in less elaborate argumentation when compared to the more open tools, in which learners build more on each others arguments. In the symposium the full results will be presented.

The work by Gijlers, Saab, van Joolingen and de Jong is based on a re-analysis of log files of students' interactions with the learning environment (including tools) as well as students' chat communication. The re-analysis focused on the relation between the nature and quality of students' communicative processes and the characteristics of the inquiry learning environment students worked with. The information extracted from the log files showed that the characteristics of different scaffolds aimed at supporting the inquiry learning process also influenced collaborative learning process and students' communication. The results provide valuable input for the development of learning materials that stimulate collaborative reasoning and elaboration.

Technology Support for In Vivo Experiments on Collaboration and Metacognition

Ken Koedinger, Carnegie-Mellon University

The Pittsburgh Science of Learning Center (PSLC) is a 5-year center, \$25 million funded by the US National Science Foundation (see learnlab.org). PSLC's main goal is to advance scientific understanding of "robust learning", learning that transfers to novel situations, is retained for long periods, and accelerates future learning. Toward that goal, we are creating technological resources that afford learning research: - faster and easier authoring of advanced educational technologies, - intelligent tutoring systems and on-line courses to run tightly-controlled experiments in classrooms, - technologies to collect fine-grained longitudinal learning data, - data sets available to researchers, - machine learning techniques for data mining. PSLC supports researchers around the world in making use of these resources in scientific investigations of robust learning. In particular, PSLC provides a means for researchers to run experiments in the context of one of seven technology-enhanced courses in math, science, and language learning. These full courses are in use in hundreds of high schools and numerous colleges and PSLC has arrangements with a number of these sites that allow tightly-controlled studies to be performed in the live context of these

courses, that is, as "in vivo learning experiments". Current in vivo studies are exploring a wide range of issues including supporting collaboration within and around intelligent tutoring systems, supporting metacognition, learning from observation, forms of self-explanation. This talk will summarize results from some of these studies including evidence that collaboration scripting improves learning in the context of the Algebra Cognitive Tutor.

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