Project Summary

The present widespread interest in the use of electronic media for learning at all levels from K-12 to university and adult education presents an unprecedented opportunity for leveraging the computational medium's strengths for learning: its representational and analytic capabilities, its interactivity and networking support for collaboration. In this opportunity lies profound responsibility to adopt or invent technologies specifically designed and proven to support learning. Decades of research on learning and instruction have shown the importance of representational aids and of social processes, such as collaboration and mentoring, to learning. Yet, there is a lack of research on how representational tools and collaborative learning may be constructively combined, and existing tools for collaboration provide only primitive support. We particularly need to understand how representations support discourse, and design representational systems in coordination with what we know, and are learning, about human knowledge-building activities. The proposed line of research will address this problem from two perspectives:

1. *From representations to learning interactions:* Any given representational system has its own affordances, restricting what can be represented and making certain information more salient than others. How can these representational affordances be leveraged to guide the content and dynamics of collaborative learning interactions?
2. *From learning interactions to representations:* How can we construct active representational media in which learners find it natural to record their discourse, problem solving activities, and emerging knowledge to support learning by reflection, mentoring, and assessment?

The proposed work will combine these two perspectives to provide explicit representational support for *artifact-centered knowledge-building discourse* in science education. Asynchronous (anytime, anyplace) collaboration will be emphasized. This work will be conducted in the context of a new K-12 SMET systemic initiative, Hawai'i Networked Learning Communities (HNLC), which is under my co-direction. HNLC is thematically focused on "global environmental studies, situated locally." It will utilize networked collaboration software, remote sensing, and electronic mentoring to address the Hawai'i Content and Performance Standards by engaging students and teachers with scientists in authentic research and conservation work. Applications of this work to Asynchronous Learning Network (ALN) versions of several of our University's degree programs are also expected. The following activities will be specifically supported by CAREER funding:

- A Ph.D. student with interests in educational technology will be recruited into our Ph.D. program and receive training as part of the following work.
- Representational systems for asynchronous collaborative learning will be developed in collaboration with HNLC teachers and scientists to help ensure suitability for instructional objectives.
- Controlled experiments will be undertaken to refine the software design and to assess theoretically important effects of the representations on discourse and on learning outcomes.
- Development of instructional and assessment strategies and evaluation of learning outcomes will be undertaken in the context of long-term support of collaborative projects between HNLC students, teachers and scientists.
- These technologies and strategies will also be utilized in our ALN undergraduate and graduate degree programs in computer science.
- New courses on Human-Computer Interaction, Designing Usable Interfaces, and Software for Learning and Work will be proposed for our curriculum, in order to expose our future information technology workers to the importance of addressing the human dimension of information systems, particularly in educational and training applications.

Continued work in this area will contribute to an empirically grounded theory of design for discourse within representationally rich collaborative learning environments and inform the design of the next generation of software and associated instructional and assessment strategies for asynchronous learning.

Project Description

There is a great deal of interest in the use of electronic media for learning, across the age spectrum from K-12 through university and lifelong learning, in both proximal and distance learning situations, and across a diversity of disciplines. This interest is driven by a number of factors pertaining to the technology itself. These factors include the falling costs of computers relative to performance, the explosive growth of the Internet in terms of size and access, perceptions of the World Wide Web as an information cornucopia, and the increasing importance of information technology itself as a subject of study in preparation for entering the workplace. Economic and social factors are also operational. Economically challenged and geographically isolated school districts need to offer an increasingly diverse curriculum in spite of limited in-house faculty expertise. Post-secondary demographics are shifting to new populations of learners who want to improve their career prospects through education, but cannot enter a campus-based program due to geographic constraints, child care, or the need to continue working. Hence, university administrators see distance learning technology as a way to reach a larger market.

This milieu presents a great opportunity for leveraging the computational medium's strengths for education: its representational and analytic capabilities, its interactivity and networking support for collaboration. Yet in this opportunity lies profound responsibility on the part of educators, policymakers and technologists to adopt technologies specifically designed and proven to support learning. We need to explore how computation enables new forms of support for interaction in learning, not just cobble together the available electronic media, nor just "deliver" conventional but ineffective pedagogical approaches over the wire.

Decades of research on learning and instruction have shown the importance of learners' active participation in expressing, testing, and revising their own knowledge (e.g., Chi, et al., 1989; Craik & Lockhart, 1972; Perkins et al. 1997; Scardamalia & Bereiter, 1994). In particular, two sets of findings are relevant to the present proposal: the impact of representational aids, such as dynamic notations, knowledge maps, simulations, etc., on individual problem solving (Kotovsky & Simon, 1990; Larkin & Simon, 1987; Novick & Hmelo, 1994; Zhang, 1997) and learning (Koedinger, 1991; Novak, 1990; Reusser, 1993; Scardamalia et al., 1992; Snir et al., 1995); and the importance of social processes such as collaboration and mentoring to learning (Brown & Campione, 1994; Lave & Wenger, 1991; Slavin, 1990; Scardamalia & Bereiter, 1991; Webb & Palincsar, 1996). Yet, there is a lack of research on how these techniques – representational tools and collaborative learning – may be constructively combined. Although a plethora of *disciplinary representations* are available (consider scientific visualizations in fields such as meteorology and physics, the various representations of molecular structure in chemistry, and modeling tools such as UML in computer science), existing tools for collaboration provide only primitive support. For example, present-day distance learning are typically composed of standard Internet media and tools such as web-pages, chat rooms and threaded discussions without reconsideration of the support they provide (or fail to provide) for learning discourse, and without coordination with disciplinary forms of representation.

There is an urgent need for empirically grounded theories of design of electronic media for discourse in learning. We particularly need to understand how representations support discourse, and design representational systems in coordination with what we know, and are learning, about human knowledge-building activities. Fundamental research is needed under two perspectives:

1. *From representations to learning interactions:* Any given representational system has its own affordances, restricting what can be represented and making certain information more salient than others. How can these representational affordances be leveraged to guide the content and dynamics of collaborative learning interactions?
2. *From learning interactions to representations:* How can we construct active representational media in which learners find it natural to record their discourse, problem solving activities, and emerging knowledge to support learning by reflection, mentoring, and assessment?

I have already begun to address some of these needs in my LIS-funded research, focusing on the first perspective above, specifically the effects of alternate representations for critical inquiry in science on verbal discourse during proximal (co-present) collaboration between learners. The proposed work will extend this research to asynchronous (anytime, anyplace) collaboration, where the use of representational tools for the discourse itself, and hence the second perspective above, becomes more critical. It will go further, combining the two perspectives to provide explicit representational support for knowledge-building discourse in science education. A preview is provided below.

The limited comparative research available suggests that the form of representations used by learners during collaborative inquiry can have a significant effect on the discourse of the collaborating learners. In brief, different forms of representations lead to different features of discourse. This effect has been shown for both representations that are constructed by learners during collaboration (Suthers, 1999) and representations used as a medium of discourse (Baker & Lund, 1997; Guzdial, 1997; Wojahn, et al., 1998). Yet such studies sometimes fail to show an effect on learning outcomes (as opposed to processes). Although time on task is a factor, learners may also need more explicit support for their knowledge-building in order for process differences to be translated into outcome differences.

A separate but related line of research on computer mediated communication (CMC) has identified several problems related to typical *discourse representations* through which people communicate online. These problems include *incoherence* due to the violation of discourse conventions for topic maintenance (Herring, 1999), and *lack of convergence*, due to the intrinsically divergent representations used in threaded discussion (Hewitt, 1997). The shared agreement or knowledge being constructed by the discourse is not made explicit by existing tools, and hence it is difficult to find relevant contributions, place one's own contribution in the relevant context, or quickly grasp and assess the outcome of the discourse (Turoff et al., 1999). In my own work I have identified the need for better online support for *artifact-centered discourse*, discourse that makes reference to and is tightly integrated with visual or textual artifacts.

The fundamental problems are a lack of integration of discourse representations with other representations, and a lack of explicit construction of the desired outcome of the collaboration, leading to weak support for online knowledge-building discourse. I will address these problems by designing an approach to CMC that supports artifact-centered discourse by linking the discourse representation with the artifacts under discussion. I will then provide a tool enabling participants to construct an explicit representation of the topics and conclusions of the discourse itself as they engage in the discourse. In learning applications, this evolving *knowledge representation* will itself become the artifact under discussion in the CMC environment. Each contribution to the discourse will be referenced to a component of the knowledge representation, improving coherence because comments are localized where they belong, and improving convergence because multiple contributions referencing a given topic are collected together. The knowledge representation will also serve as a summary of the status of the collaboration, available to learners and mentors to support reflection and assessment.

This work will be conducted in the context of K-12 initiative in science, math, engineering and technology (SMET) education, presently funded by NSF's Rural Systemic Initiatives and under my co-direction. Our initiative, known as Hawai'i Networked Learning Communities (HNLC, http://lilt.ics.hawaii.edu/hnlc/), is thematically focused on "global environmental studies, situated locally." It will utilize networked collaboration software, remote sensing, and electronic mentoring to address the Hawai'i Content and Performance Standards by engaging students and teachers with scientists in authentic research and conservation work. Applications of this work to Asynchronous Learning Network (ALN; Mayadas, 1997) versions of several of our University's degree programs (http://www.aln.hawaii.edu/, funded by the Sloan Foundation under my co-direction), are also expected but will not be the primary focus under the present proposal. The work under CAREER funding will include the following activities:

- A Ph.D. student with interests in educational technology will be recruited into our Ph.D. program and receive training as part of the following work.
- Representational systems will be developed in collaboration with HNLC teachers and scientists to help ensure suitability for instructional objectives.
- Controlled experiments will be undertaken to refine the software design and to assess effects of the design on discourse and on learning outcomes.
- The software will be used to support long term collaborative projects between students, teachers and scientists engaged in asynchronous collaboration on SMET projects. This will enable study of appropriation and use of the tool, inform a process of iterative refinement, and likely suggest new research issues.
- Working with teachers and colleagues, we will study the possible use of knowledge representations as a means of assessment for collaborative projects undertaken by groups over the Internet, which is more difficult to assess than traditional individual classroom work.
- These technologies and strategies will also be utilized in our ALN undergraduate and graduate degree programs in computer science.

- New courses on Human-Computer Interaction, Designing Usable Interfaces, and Software for Learning and Work will be proposed for our curriculum, in order to expose our future information technology workers to the importance of addressing the human dimension of information systems, particularly in educational and training applications.

The remainder of the proposal is organized as follows. First, I summarize my research on representational guidance for proximal collaborative learning, including theoretical background and results of prior NSF support. Then I summarize problems with current CMC tools, focusing on artifact-centered discourse, and propose a solution. I then propose a way to combine the work on representational guidance with the work on CMC that is specifically oriented towards knowledge-building discourse in K-14 science education contexts. With this background, I summarize my research and educational plans and timeline, and describe resources such as collaborating projects and an advisory board.

Representational Guidance

In this section I introduce the idea that the type of external (visual and textual) representations that learners create and manipulate in the process of expressing and revising their emerging knowledge may have significant effects on collaborative learning processes and learning outcomes. Collins & Ferguson's (1993) "epistemic forms/games" and Roschelle's (1994) argument that external representations serve to mediate collaborative inquiry inspired this idea.

I also report on results of my current research on the topic, which is funded by NSF's Learning and Intelligent Systems (LIS) program. This work was initiated based on the observation that various software environments that were developed for the common goal of supporting critical inquiry in a collaborative learning context were using radically different representational systems, such as hypertext/hypermedia (Guzdial et al., 1997; O'Neill & Gomez, 1994; Scardamalia et al., 1992; Wan & Johnson, 1994); node-link graphs representing rhetorical, logical, or evidential relationships between assertions (Ranney et al., 1995; Smolensky et al., 1987; Suthers et al., 1997; Suthers & Weiner, 1995); containers or "claim frames" (Bell, 1997), and evidence or criteria matrices (Puntambekar et al., 1997). Yet, little systematic research had been undertaken to explore possible effects of this variable on collaborative learning (except Guzdial, 1997).

Summary of Theoretical Background

The major hypothesis of both the current and proposed work is that certain representational features of software used by learners will have educationally significant effects on the learners' discourse (including verbal and written discourse and other interactions such as gestures). I distinguish between representational *notations*, the representational *tools* (e.g., software) in which these notations are realized, and representational *artifacts* that one might construct in a notation using a tool. Each given representational notation manifests a particular *representational guidance***,** expressing certain aspects of one's knowledge better than others do. Representational guidance includes *constraints:* limits on expressiveness, and on the sequence in which information can be expressed (Reader, 1997; Stenning & Oberlander, 1995) and *salience:* how the representation facilitates processing of certain information, possibly at the expense of others (Larkin & Simon, 1987). Representational guidance originates in the notation, but affects the user through both the tool and artifacts constructed in the tool.

The thesis of the LIS-funded work may be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to express their emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. Representational guidance constrains which knowledge can be expressed in the shared context, and makes some of that knowledge more salient and hence a likely topic of discussion. The LIS-funded work tests the hypothesis that this representational guidance influences discourse and learning outcomes in ways that can be predicted from the constraints and salience of the notation. This research is driven by three component hypotheses.

1. *Representational Notations Bias Learners Towards Particular Ontologies.* A representational notation provides a set of primitive elements out of which representational artifacts are constructed. Learners will see their task in part as one of making acceptable representational artifacts out of these primitives. Thus, they will be guided to think about the task domain in terms of the underlying ontology.
2. *Salient Knowledge Units Receive More Elaboration.* Learners will be more likely to attend to, and hence elaborate on, the knowledge elements that are perceptually salient in their shared representational workspace than those that are either not salient or for which a representational proxy has not been created. Two

representational notations that differ in kinds of knowledge they make salient will encourage elaboration on different kinds of knowledge.

3. *Salience of Missing Knowledge Units Guides Search for New Knowledge.* If the representational notation provides structures with predetermined "fields" (or functional equivalents) for organizing knowledge elements, and unfilled fields in these organizing structures are perceptually salient, then learners will try to fill these fields.

Based on these considerations, I made the following predictions concerning Text, Graph, Container, and Matrix representations:

1. There will be more discussion of the epistemological status of statements (empirical or theoretical) in representations that require classification of statements of such. Furthermore, the effect will be greatest where the classification is represented by an explicit visual feature rather than implicitly: Text < Container < Matrix < Graph.
2. There will be more discussion about the evidential relationships between statements when a representation of such relationships is provided. The effect will be greater when relationships are represented with an explicit object (a link or an annotation) rather than merely by spatial placement, and greatest when all possible relationships are prompted for by empty fields: Text < Container < Graph < Matrix.
3. Participants will be more likely to elaborate on ideas that were salient in the representation than those that are not represented or not salient in the representation.

Space constraints disallow detailed description of these hypotheses and predictions, which may be found in the original LIS proposal or in Suthers (1999e). It should be noted that the "<" symbol expresses predictions about effects on discourse processes, and does not make a value judgement. Whether and when more talk about epistemological status and/or evidential relations is desirable is a separate instructional decision.

Prior Results

I report on a project entitled "The Effects of Representational Bias on Collaborative Learning Interactions," funded by NSF's LIS program (#9873516, $461,462, Oct. 1, 1998-Sept. 30, 2001) to provide background for the proposed new work, as well as to comply with reporting requirements.

Pilot Study

We analyzed a pilot study undertaken to refine experimental and analytic techniques and demonstrate the phenomenon to be studied. The study distributed six pairs of middle school boys (12 participants) evenly between three treatment conditions in a between-subjects design. Treatment conditions corresponded to three software packages: Microsoft Word (Text), Microsoft Excel (Matrix), and Belvedere (Graph). Groups using Excel were provided with a prepared matrix that had the labels "Hypotheses" and "Data" in the upper left corner, and cells formatted sufficiently large to allow entry of textual summaries. Participants were specifically told to enter hypotheses as column headers, data as row headers, and to record the relationships in the internal cells. The Graph condition used Belvedere (Suthers & Weiner, 1995; Suthers et al., 1997; Toth et al., 2000), an *evidence mapping* tool developed under the direction of Alan Lesgold and I at the University of Pittsburgh. The version of Belvedere used (2.1) provides rounded nodes for hypotheses, rectangles for data, and links for consistency and inconsistency relations between them. Hypothesis and data shapes are filled with textual summaries of the corresponding claims.

Participants were seated in front of a computer screen containing the representational tool and a web browser open to the entry page for a *science challenge problem*. The problem presented a phenomenon to be explained (e.g., determining the cause a mysterious disease on Guam), along with indices to brief online articles posing possible explanations, reporting empirical findings from fieldwork or laboratory work, or explaining basic domain concepts. Participants were instructed to identify hypotheses that provide candidate explanations of the phenomenon posed, and to evaluate these hypotheses based on the online materials. They were instructed to use the representational tool during the problem solving session to record the information they find and explore how it bears on the problem.

Videotapes from the six one-hour problem-solving sessions were transcribed and coded for types of discourse. Coding was performed by two of my assistants. Inter-rater reliability (kappa) was 0.92 (n=1942). Addressing the first (ontological) hypothesis, we found that 5.6% of Text, 7.1% of Matrix and 9.3% of Graph utterances were concerned with the classification of new information as *data* versus *hypothesis* or their equivalents. We believe that Text would have been lower, except that the instructions for all three conditions directed participants to consider and record hypotheses and empirical evidence. Text participants, like others, complied with these instructions, for example, by labeling propositions as “Data” or Hypothesis.” Graph’s greater proportion of epistemological classification talk is explained by its most explicit use of visually distinct shapes to represent data and hypotheses. The percentages of verbal segments concerned with questions of evidence are consistent with the second hypothesis: Text=0.6% < Graph=5.2% < Matrix=19.7%. In Text and Graph, participants focused primarily on Consistency relations, a possible manifestation of the confirmation bias (but see Klayman & Ha, 1987). Discussion of evidence was more balanced in Matrix, with almost half of the talk about evidential relations being concerned with inconsistency or equivocal relations. This may be because Matrix prompts for consideration of relationships between all pairs of items: participants are more likely to encounter inconsistency or indeterminate relations when considering those they may have neglected in the Graph or Text conditions. The third hypothesis was deferred until the full study, as this requires more control over presentation of materials and an analysis that is sensitive to the state of the representation.

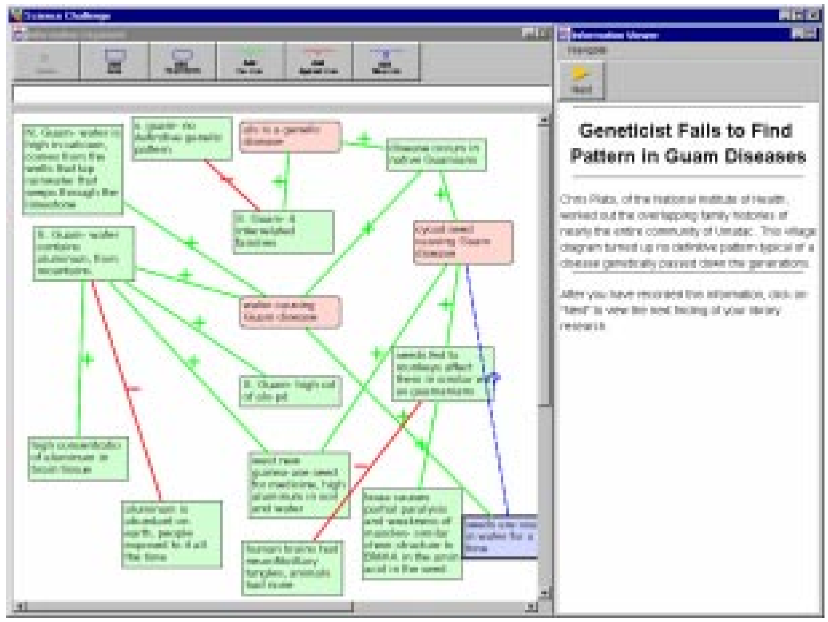

Figure 1. Graph from representational guidance study

Overall, the results were encouraging. Differences in the predicted directions were seen in both talk about evidence and about the epistemological status of statements. Qualitative observations were also informative, but cannot be discussed here for space reasons.

Full Study

We then undertook a full study with a sample size large enough for statistical testing. My graduate assistants and independent study students modified the Belvedere software to support this research. The experimental interface is shown in Figure 1 (Graph view only).We updated the Graph view and implemented Matrix, Container, and Tree views of evidential models. Tree is a hierarchical list of the different types of objects in the model: see Figure 2. We also prepared a more structured version of the science challenge that presents information in a controlled order, and prepared a posttest based on this material. We conducted several months of pilot sessions and data analyses, iteratively refining the software, materials, and coding scheme. LIS-funded collaborations with Micki Chi were instrumental in these preparations. In the spring of 2000, we ran the full study, involving a minimum of 10 groups per each of three conditions. At this writing, we have completed transcription of the videotapes and begun coding. We have scored the information recall posttests, with no significant difference found between groups. This was not a surprise, given the short learning period (one hour) of the laboratory studies, which motivates my plan to use longer learning periods in both laboratory and field studies in the proposed CAREER work.

Belvedere 3.0: Multiple Views on Evidence Models

I conducted an experimental comparison of various representations of evidential relations because I wanted to understand how representational affordances affect the work of collaborating learners, not because I viewed them as mutually exclusive. To the contrary, all representations that have some utility should be available to learners, and educators should learn to develop the *representational competency* of their students: the ability to choose an appropriate representation for a task and to translate between representations. To this end, we (in a series of independent study programming projects) have just finished implementing the first version of a *multiple view* version of Belvedere (Figure 2). We now think of students as constructing evidence *models*, which may be displayed under different representational *views.* Belvedere 3.0 provides Graph, Matrix and Tree views of evidence models.

Users can construct evidence models under any of these views, switching freely between them as desired. This multiple-view software will receive trial use in a classroom beginning in August 2000.

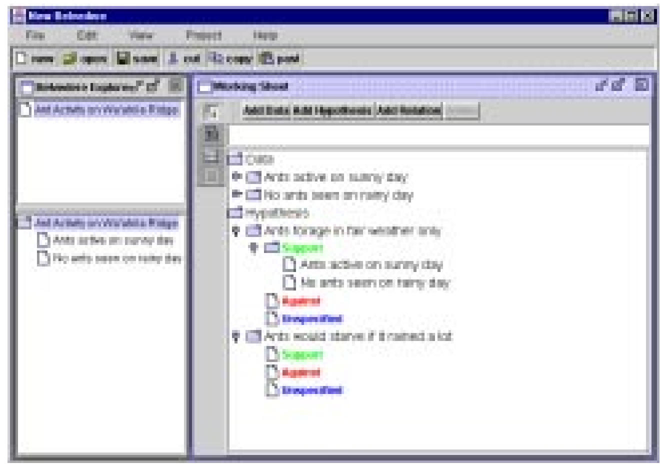

Figure 2. Tree View in Multiple View Belvedere

Other Results

I briefly note a few other products of the LIS funding. My postdoctoral student, Christopher Hundhausen, received substantial training and showed enough promise to be hired as a full time faculty in our department, enabling us to initiate a long-term collaboration. I graduated one Master's student with a thesis that compared alternate software architectures for collaborative learning systems. A dozen students worked with me on related independent study projects. I also co-organized a workshop at the 1999 Computer Supported Collaborative Learning conference entitled “Collaborative Representations: Analyzing Learning Interactions” in which participants took a detailed look at five video-taped examples of students collaborating while learning using various representational tools (http://lilt.ics.hawaii.edu/CSCL99/CollaborativeReps/). Finally, five directly related conference papers (Suthers, 1999a-1999e) and two indirectly related articles (Koedinger, et al., 1999; Roschelle, et al., 1999) were published, and two journal articles are under review (Suthers, 2000; Toth, et al., 2000).

Remaining Work

In the final year of the LIS project we will be occupied with analysis of the substantial data we have collected. I also plan to conduct a small study in which participants interact at a distance via a “chat” window instead of face to face. This will enable a comparison of how the roles of representations change when grounding costs increase (Clark & Brennan, 1991) because participants can no longer gesture directly at objects and lack the implicit awareness of the other’s orientation towards the shared artifact.

The research just outlined is providing the first systematic comparison of several representations as they affect collaborative learning. Yet, the LIS-funded studies will examine only a small number of representations, namely those commonly used in collaborative learning software for evidence-driven scientific reasoning, with primarily co-present learners and a single task. Substantial work is needed to examine the relationships between representational guidance and discourse using other representations, different tasks and populations, and in distance interaction as well as proximal situations. Study of alternate forms of support for distance interaction is outside the scope of the LIS-funded project. The CAREER funding will enable continuation of this ongoing research program, focusing on *asynchronous collaborative learning*. In particular, the CAREER research will expand my studies under perspective #1, the effects of representational guidance on collaborative discourse and learning, to asynchronous learning paradigms, and begin investigations under perspective #2, the design of representations through which quality learning discourse can take place. These two perspectives on collaborative representations will be integrated by investigations into how the combination of disciplinary and discourse representations can mutually improve knowledge-building discourse in asynchronous collaborative learning contexts. In the next section I motivate the work under perspective #2, representations for discourse, before turning to the integration and its application to K-12 SMET education.

Discourse Representations for Asynchronous Collaborative Learning

There is a significant trend towards computer mediated distance collaboration in educational contexts ranging from K-12 through university to life-long professional development of adults. This trend is exemplified by two projects in which I am involved (HNLC and UH-ALN, to be described later). In these applications, substantial issues arise concerning the design of representational media *for* conversation – *discourse representations* – in addition to the design of representational media *about* which conversation takes place – *disciplinary* and *knowledge representations*. In particular, there is a need to better understand how discourse, disciplinary and knowledge representations are used together in asynchronous collaboration contexts, and to design discourse representations for more effective coordination with the other two. My CAREER funded research will investigate this problem in asynchronous collaborative learning applications.

Issues in Computer Mediated Communication

Computer Mediated Communication (CMC) is an active area of research specifically concerned with the effects of various electronic media on quality of group interaction. For example, studies show mixed results concerning the common claim that participation is more balanced in online discourse because there is no competition for “the floor” as in face to face communication (Bordia, 1997; Herring 1993; Sproull, 1986). A large body of research concerned with comparisons between *types* of media for education (e.g., electronic correspondence, videoconferencing and traditional classroom instruction) repeatedly shows that there is no significant difference in learning outcomes (Russell, 1999). This research typically does not study design choices (such as representations) *within* a given medium.

Other work documents problems with conventional CMC discourse tools such as “chat rooms” and threaded discussions. Problems of incoherence can be traced to bandwidth and timing problems (Herring, 1999); while lack of convergence is due in part to the inherent divergence of the hierarchical reply structure (Hewitt, 1997). Threaded discussion, one of the most richly structured forms of CMC, organizes contributions under subject “threads” using reply and chronology relations. This representation is based on the historical development of the discussion rather than its conceptual content, making it difficult to quickly grasp and assess the status of the discourse and hence to make contributions that move it forward (Turoff, et al., 1999). The addition of categorical labels on contributions (e.g., Hoadly et al., 1995; Sloffer, et al., 1999) can provide information about their intended role, yet does not escape the fact that the primary organization is an artifact of the discourse history. Similarly, CSILE’s “knowledge maps” (Hewitt & Scardamalia, 1998) are not knowledge maps at all, but rather maps of reference relations between contributions. My proposed research will address many of these problems by studying how construction of explicit knowledge representations can help focus online collaborative learning discourse. Thus there will be at least two representations manipulated by learners: of their discourse and their knowledge. This brings us to another weakness of most existing CMC technology.

Forms of Artifact-Centered Discourse in CMC

In face to face discussions we often reference and manipulate external artifacts (sketches, pictures, and objects). Interaction with the artifacts is an essential part of the work of the participants. This will also be true – or should be true – of online learning. For example, students in our Hawai’i Networked Learning Communities initiative will need to discuss various forms of *disciplinary representations*, such as remote sensor data, and *knowledge representations*, such as interpretations of that data. Yet the online world provides only impoverished support for discourse about artifacts. Many products for CMC or Asynchronous Learning Networks (ALN, “anytime anyplace” learning via the Internet, Maydas, 1997) are not designed to establish and carry on a discussion in the context of a visual artifact that can be annotated and referenced. Other tools support annotation of textual artifacts, but do not support discourse beyond these localized comments. I briefly review these two extremes before proposing an alternative.

Parallel CMC

In typical ALN tools (such as WebCT, http://www.webct.com/), the discourse representations are used in alternation with or side by side with a disciplinary representation. I call this *parallel CMC* because they are used in parallel: there is no communication or coordination between the discourse and disciplinary representations. Microsoft’s NetMeeting (http://www.microsoft.com/windows/netmeeting/) is a well-known synchronous example: one can share applications and carry on discussions in a separate chat window. In informal studies conducted by two of my directed study students, users provided with NetMeeting preferred to embed their discussion directly in the disciplinary artifact (as comments in a software program being debugged) rather than switching

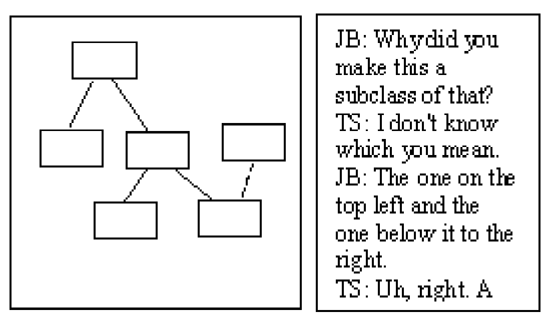

Figure 3. Parallel CMC

between the artifact and chat. Although screen space and cursor control were also factors in these sessions, this preference may be understood in terms of cognitive load theory (Sweller et al., 1998). Tasks and materials that require split attention between two sources of information that must be integrated lead to increased cognitive load. It is Physically merging the two sources of information can reduce this load, motivating the next form of CMC to be discussed. Another problem is that deictic reference must be accomplished through sometimes-awkward linguistic means, as suggested by the hypothetical example of Figure 3.

Embedded CMC

An *embedded* discourse representation embeds comments directly on or in the display of the artifact under discussion. For example, the University of Hawai'i's Outreach College has developed an environment for online communities known as Maile (http://www.maile.hawaii.edu/) which is now in active use at the University. In Maile's Writing Exchange, students can post samples of their writing, whereupon others can insert their comments directly in the original prose. Other examples include Microsoft Word's comment facility and CoNote (Davis & Huttenlocher, 1995). Figure 4 shows a hypothetical example of notes attached to nodes and links in a diagram.

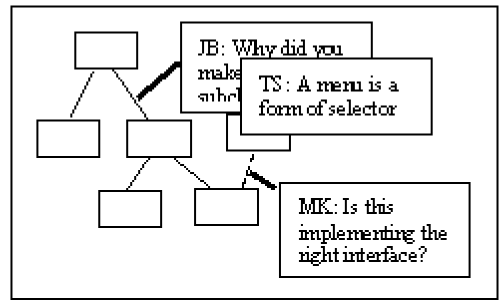

Figure 4. Embedded CMC

Some empirical evidence supports the embedded approach. Guzdial (1997) compared "anchored collaboration" (embedding links to discussion threads within artifacts of interest) to newsgroups in undergraduate classes, finding that longer threads of discussion took place with anchored collaboration. Wojahn, *et al.* (1998) performed an experimental comparison of "split-screen," "interlinear" (embedded) and "aligned" (side by side) interfaces for collaborative annotations, and found no significant difference in time to task completion but significantly fewer communications in the split-screen representation, which apparently presents the greatest distance between the artifact and the annotations, and hence cognitive load in processing them.

Because the discourse always takes place in the context of the artifact, embedded CMC has the advantages that it is easier to refer to parts of the artifact or to recover the portion of the discussion that is concerned with a given part. Disadvantages include the fact that the record of discourse is fragmented across the artifact, making it more difficult to get a sense of the whole discussion or to notice relevant relations between discussions about different parts of the artifact, as well as the possibility that the artifact becomes cluttered with comments. We would like to be able to recover chronological versions of the discourse, and perhaps to index into the discourse in different ways other than by artifact component or by chronology.

Linked CMC

The tradeoff between parallel and embedded CMC can be resolved by providing discourse and artifacts with independent representations optimized for the needs of each, but providing a logical linkage between the two that can be viewed in virtually embedded ways if needed. Such *linked CMC* representations might take several forms. In one form, discourse and disciplinary representations are displayed side by side, as in Parallel-CMC, retaining the reply structure and chronology of the discourse. The difference is that all contributions are referenced to an object or region in the disciplinary representation: one or more objects *must* be selected before entering a note. Selection of a discourse contribution would result in highlighting of the object discussed by that contribution, disambiguating terms such as "this" and "that." Selection of a disciplinary object would result in highlighting of the relevant discourse contributions.

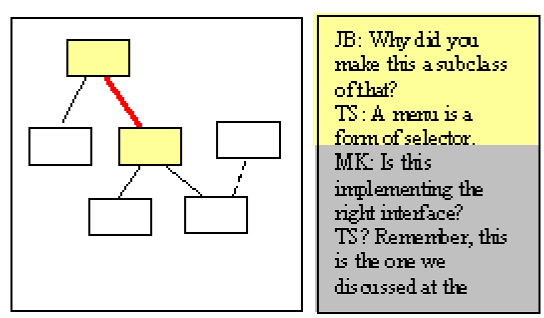

Figure 5. Linked CMC

We need not limit ourselves to one displayed representation. It should be possible to switch between parallel and embedded representations. One should be able to create a note in one representation and view it in another. For example, see Figure 6. In step 1, a user attaches an embedded note to a link in the diagram. In step 2, another user responds to this note. Later on, in step 3 a user is reviewing the comments on the diagram, using a chronological but linked display. This user can select objects in the diagram to have all the relevant comments highlighted in the chronological display, or can select notes in the chronological display to have the objects that are being discussed highlighted.

This approach resolves the tradeoff between the typically linear structures of parallel discourse tools and the contextual indexing of embedded discourse representations. My hypothesis is that linked CMC, properly designed, can improve coherence and convergence of CMC by collecting together topically related contributions. This is a general solution, applicable to any online artifact-centered discourse, but I am particularly interested in its applications to supporting knowledge-building discourse within learning communities.

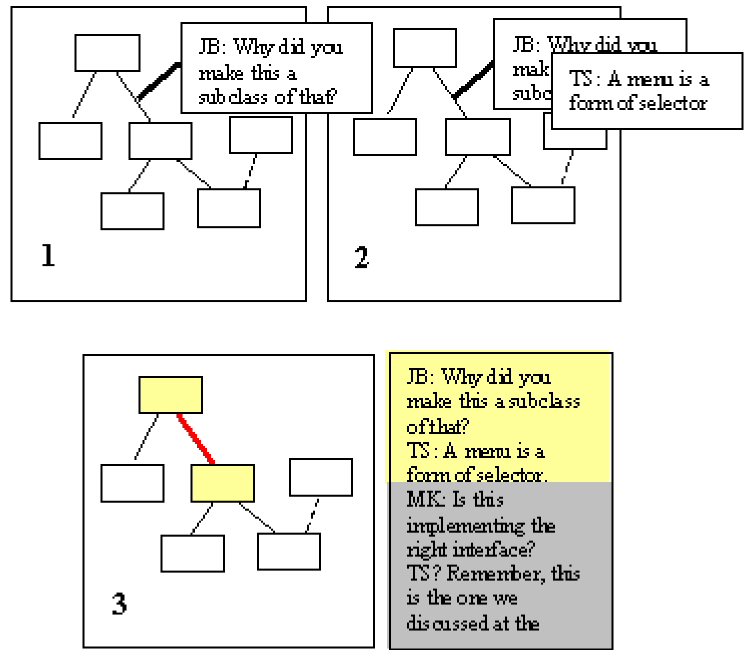

Figure 6. Multiple Views on Linked CMC

Supporting Online Knowledge-Building Discourse

Up to this point I have described two lines of research. One (perspective #1) works from knowledge representations to discourse, exploring how the design of representations for critical inquiry might improve the quality of collaborative learning discourse. The other (perspective #2) works from discourse to representations, exploring how representations might be improved to better support and record artifact-centered discourse. In this section I describe how these two lines of work converge to support online knowledge-building discourse.

The key idea is to have learners use an inquiry-oriented representation to capture their emerging knowledge, and make this knowledge representation itself a subject of artifact-centered discourse (alongside other disciplinary representations). The artifact under discussion is also a representation of the knowledge emerging from that discussion, for example, an evidence map or concept map (Novak, 1990). This knowledge representation helps support the quality of the online discourse because (1) the representational primitives were designed to guide effective discourse and because (2) it provides, via the Linked CMC facility, a way to focus the discourse, anchoring contributions in terms of their relevance, maintaining coherence and encouraging convergence. In summary, it is a synergistic arrangement: the discourse helps build the conceptual representations that improve the quality and productivity of the discourse. It fills the missing "middle space between communication and information interfaces" (Hoadley & Enyedy, 1999).

Disciplinary representations such as graphs of data, pictures, and simulations provide foundations for knowledge-building. They should also be available for inspection and discussion. I plan to experiment with ways to integrate discourse, knowledge, and disciplinary representations, generally working as follows. When a user wants to make a new contribution to the discussion, that user either selects one or more objects in the knowledge representation or creates a new one. An object in the knowledge representation may be associated with a disciplinary representation, which will be displayed in a different panel when that object is selected. Other users encountering this material later on can select the object in the knowledge representation and see both the associated disciplinary representation and the associated discourse. The result is that all discourse is referenced to the knowledge representation being built and the disciplinary representations on which the work is based, focusing the discourse and making it easier to find relevant contributions later. This knowledge-building environment can be created most expediently by modifying the Belvedere software (my students have already begun work on it).

The CAREER work will not focus on software development. Instead, the focus will be on (1) laboratory research aimed at (a) optimizing the design of this genre of software for artifact-centered knowledge building discourse and at (b) refining an underlying theory of representational design; and (2) field research aimed at (c) understanding ways in which such software is appropriated by communities engaged in asynchronous collaborative learning, and at (b) developing practices and materials that maximize the effectiveness of the software for learning in such communities.

I have two research hypotheses concerning this linkage between discourse, disciplinary, and knowledge representations. First, learner-constructed knowledge representations will be better suited for solving problems of coherence and convergence than the reply and chronology relations of typical threaded discussion tools. Second, learning outcomes (not just process differences) will be enhanced because of the dual advantage that discussion occurs in the context of disciplinary artifacts and the knowledge representations play a continuing functional role in supporting discourse.

I have three further hypotheses concerning use of this integrated knowledge-building environment in practice. First, teachers adopting this technology will be able to focus more on learning objectives than with conventional technology because it explicitly prompts for knowledge-building. The teacher can immediately address the question of how to arrange knowledge-building situations, rather than with how to circumvent pedagogically awkward features of technology. (My work with the Hawai'i Department of Education will provide professional development towards this end.) Second, these representations will enable us to develop methods of assessing group collaboration in online learning because they provide a summary knowledge representation with links back to a record of the discourse process. Third, when coupled with the knowledge building situations and assessment methods just mentioned, the learning outcomes seen in the laboratory will also be seen, perhaps enhanced, in practicing communities.

Career Plans

The foregoing has provided a picture of the kinds of issues I am concerned with in the development of rich educational media for online collaborative learning. In this section I describe how these interests will be organized over the next five years. These plans may be amended in response to outcomes of studies undertaken during the earlier years.

Research Activities

All of the research hypotheses listed above will be addressed to some extent over the funded period, although to varying degrees of intensity and at different periods as the work progresses from design to laboratory research and intensive studies in application. CAREER funding will provide the core resources, but additional funding will be sought to provide further resources necessary to undertake this ambitious program.

Design Activities, Usability Testing, and Controlled Studies

The research will begin with work in my Laboratory for Interactive Learning Technologies (http://lilt.ics.hawaii.edu), including design of suitable representations in collaboration with teachers and scientists, implementation and usability testing of software, and controlled studies undertaken to test design alternatives and their underlying hypotheses.

Questions pertaining to how notations for learner-constructed knowledge representations can provide affordances for more effective collaborative learning (the topic of my present LIS-funded research) will be a focus of the CAREER-funded research only to the extent that it bears on the support of online knowledge-building discourse. Within each application area we explore in our Hawai'i Networked Learning Communities (HNLC) collaborations I will investigate how to arrange the representational toolkit available to learners to focus their discourse on the most important conceptual and epistemological issues. Representational systems will be developed in collaboration with HNLC teachers and scientists to help ensure suitability for instructional objectives. Representations will initially be tested in the laboratory using asynchronous versions of the "science challenge" paradigm of my present studies (described earlier in the proposal), and then will be further refined by adoption to supporting collaboration among HNLC learners and mentors. A full scale comparative study will only be undertaken if a substantial and unresolved design choice arises that has theoretical implications.

Questions pertaining to how online discourse representations can be better integrated with artifacts under discussion merit some investigation to provide the necessary background for the remaining work. A controlled study will compare Parallel, Embedded, and Linked CMC to establish their relative merits and the advantages of Linked CMC in the context of a knowledge-building activity. Participants will be required to solve a problem that involves discussion, over time, of the components of a representation that they are constructing. For expediency these studies will use a Belvedere evidence map as the referenced artifact and a science challenge problem similar to those in my present LIS-funded research. Participants in this asynchronous study will be expected to return to the online environment twice a week for several weeks. Each time, each participant will receive some new information that bears upon the investigation. The participant's tasks will be to examine and reply to changes made by other participants, and to integrate their own new information into the knowledge-building forum.

Data analysis will include both process and learning outcome measures. Process will be assessed by discourse analysis of referential overhead (greater ease of referring to objects in the representation should translate into proportionally more of the communications focused on substantial issues), coherence (ways in which related contributions are grouped and referenced), and convergence (identifiable conclusions reached by the discussion). Outcome measures will examine quality of the evidence maps in terms of integration of evidence with hypotheses, particularly where coordination of data distributed across participants is important, and performance on a post-test of factual memory and appreciation of the significance of items of evidence. I will consider these studies successful if differences in quality of learning process, solution quality, and especially learning outcomes are demonstrated, particularly if these differences can be accounted for in terms of the representational affordances of the different forms of CMC. Several variations and follow-up studies can be envisioned but will depend on the outcome of the initial work.

I expect that one or more methodological advances for analyzing collaborative use of representations will result from this work. Under my present funding we developing techniques to track the introduction and reintroduction of information into focus of group attention as a function of representational state, and analyzing how changes of representational state correlate with subsequent discourse. Future plans include use of referential analysis to identify representational semantics in the eyes of the learners (thanks to suggestions from Susan Goldman, Tim Koschmann, and Keith Stenning). I expect that other analytic innovations would result as we push this work further and adopt it to asynchronous collaboration contexts. Asynchronous collaborative learning itself presents a methodological challenge: we will need to develop experimental paradigms for studying ALN-supported collaborations over an extended period of time in controlled settings.

Supporting Networked Learning Communities in K-12 Science Education

I was proposal author and am co-PI on an initiative entitled "Hawai'i Networked Learning Communities" (HNLC, http://lilt.ics.hawaii.edu/hnlc/) funded by the NSF Rural Systemic Initiatives (RSI) program under a development grant. The other PIs are Violet Harada of the Library and Information Sciences Program in the Department of Information and Computer Sciences, University of Hawai'i at Manoa, and Vicki Kajioka of the Advanced Technology Research (ATR) Office of the Hawai'i Department of Education. Under the direction of Superintendent Paul LeMahieu, the Hawai'i DOE is currently engaged in a process of standards-based systemic reform. The HNLC consortium of business, government, and educational organizations statewide seeks to support this effort. We are presently preparing a five-year implementation proposal to RSI. My CAREER funded research will dovetail with HNLC: I will collaborate with HNLC students, teachers and scientists in both the design and use of collaborative representations for education. (See letter of commitment from Assistant Superintendent Diana Oshiro in appendices. The collaborations described below will be undertaken regardless of whether we receive RSI funding.) Hawai'i is unique in having one school district for the entire state, a situation that will enable both my HNLC and CAREER work to address applications at a systemic level.

The basic concept of HNLC is as follows. Hawai'i's small rural schools do not have, and cannot be expected to sustain, a faculty with expertise in a full range of science and technology disciplines. This situation is ironic given that Hawai'i manifests a rich range of natural phenomena and is the home of science and technology resources used by scientists worldwide. HNLC will provide Hawai'i's rural students with access to these resources through distance collaboration and remote sensing technology, under a theme of "global environmental studies, situated locally" and in coordination with the state's strategic plan for systemic standards-based reform. We have conceived of a number of ways in which students can participate in advanced science and technology projects while also providing benefits to the practitioners involved. For example, students will work with radio-linked weather stations and cameras placed in remote locations and trained on individuals of endangered plant species, conduct systematic sky surveys with research grade telescopes under the guidance of community college students, or participate in the ecological restoration of an ancient Hawai'ian unit of land management. This initiative will involve extensive use of distance collaboration and asynchronous learning technology, and hence will be a source of ideas for as well as a test-bed for my CAREER-funded research. A related objective of HNLC is the exploration of alternative methods for assessment in science, including use of knowledge mapping tools such as Belvedere.

The integrated knowledge-building environment will be used to support long-term collaborative projects between students, teachers and scientists engaged in asynchronous collaboration on SMET projects within HNLC. This will enable study of use and appropriation of the tool, inform a process of iterative refinement, and likely suggest new research issues. An important component will be the development of curricular resources and instructional and assessment strategies that necessarily work hand in hand with any technological innovation for education (Suthers et al., 1997, Tabak & Reiser, 1997).

My colleague Vicki Kajioka has developed a program called Technology and Telecommunications for Teachers (T3), designed to prepare school leaders who will infuse appropriate technology into instruction to enhance student learning. Participants learn to apply a variety of technologies, and receive professional development credits for their work. T3 maintains a community of expert teachers who mentor others in the use of technology. Collaborators will be recruited from this community to help me design the representations, test the usability of the software, and develop instructional and implementation strategies for use of the software in support of asynchronous learning communities. I have budgeted travel and honoraria for these teachers for the first three years, tapering off in the third. Working scientists who are participating in HNLC will also be involved, including Kim Bridges, a Botanist who is aggressively innovative in the use of technology for education, and others from the School of Ocean and Earth Science and Technology's Sea Grant, under the direction of Gordon Grau. Beginning in the third year I expect that my project will have begun to reach a level of maturity where it can form the basis for teacher professional development and support ongoing learning communities. Vicki Kajioka has agreed to include this technology as a topic in the T3 program. (See letter of support from her supervisor, Assistant Superintendent Diana Oshiro.) Hence beginning in the third year I have budgeted travel for teachers who will learn to develop distributed learning communities in their classes, and obtain professional development credits (instead of honoraria) for their efforts.

Effectiveness of the approach in practice will be evaluated several ways. I will seek collaborations with HNLC teachers using other CMC tools as well as those using the integrated environment. In both cases, I will obtain traces of students' CMC and their final reports or products, and compare them for quality of discourse and conclusions reached. Selected classroom observations will be conducted, primarily to gain firsthand experience and identify problems and new potentials to explore (resources are too limited to rely on this as a primary data source). Teachers will also provide their own evaluation through reports to me and indirectly by their choice of software in subsequent years. I will consider this work successful if we are able to create sustained communities of asynchronous collaborative learners who elect to continue using the collaborative representation software and associated instructional strategies, and if we find evidence of high quality knowledge building discourse in their use of the software.

Working with teachers and colleagues, I will study the use of the knowledge representations as a means of assessment for group work. Collaborative projects undertaken by groups over the Internet are more difficult to assess than traditional individual classroom work. Could teachers use the knowledge representations to assess the work of a group of students? Could mentors use it to guide teachers and students? My colleague Violet Harada (co-PI of HNLC and associate professor of Library and Information Science in ICS) and I will be initiating this work with focus groups of teachers from HNLC in the fall of 2000, using the present Belvedere software. CAREER funding will help ensure continued development of a line of knowledge modeling tools that are attuned to our educators' assessment needs in meeting the Hawai'i Content and Performance Standards.

Additional Educational Activities

The research activities outlined above are centrally concerned with education. I include this section to describe other educational activities and implications that were not covered above.

UH- ALN: Collaborative Apprenticeships in Computer Science

The proposed CAREER work is relevant to a major priority of our department: the development of distance education versions of our Masters and Bachelors degree programs. Due to unprecedented demand and salary levels in industry, many computer science students leave their graduate programs prematurely, and other qualified and talented students defer or decline admittance to graduate study for economic reasons. The result is a high tech work force that lacks the advanced knowledge and skills needed to produce the innovations that will drive the high tech industry of the future. Distance education through asynchronous learning networks (ALN) has the potential to significantly reduce this problem by enabling professionals to acquire advanced skills through graduate study without leaving their industrial positions. I am co-PI on a project funded by the Sloan Foundation for development of ALN versions of our ICS Bachelor's and Masters degree program as well as other degrees (http://www.aln.hawaii.edu/). The other PIs are Victor Kobayashi, Dean of Outreach College (our continuing/summer/distance education branch) and Jaishree Odin of Liberal Studies.

A key component of a high quality computer science graduate program is intensive collaboration and apprenticeship with faculty and with other students on the design, implementation, and evaluation of innovative software technology. We intend to provide the technological and methodological infrastructure necessary for such collaborative apprenticeships by life-long learners at a distance. Representationally rich distance collaboration technology will play an important role in this work. For example, facilities for talking about the artifacts of software engineering (e.g., interface mockups, class diagrams, source code) will become increasingly important as our degrees go online. The proposed CAREER research and educational activities will help inform our department's choice of technology for the ALN degrees. My own teaching via ALN will also provide me with an opportunity to try out the ideas and software discussed in this proposal with a different topic (computer science) and different populations (undergraduates and graduates) than the HNLC work.

Curriculum Development

Our department has recently hired a new faculty member with expertise in Human-Computer Interaction (HCI) – namely, Chris Hundhausen, who was my postdoc under NSF LIS funding. Along with Martha Crosby in ICS and several other faculty in other departments (all of whom have interests in educational applications), this provides us with "critical mass" in HCI, a fact we intend to leverage in creating an HCI emphasis in our curriculum. Early in the CAREER funded period I will be submitting a curriculum proposal to augment our current single HCI graduate course with three others, to provide an introductory HCI course and a hands-on course in "Designing Usable Interfaces" at both the undergraduate and graduate levels.

I also plan to add a graduate course in "Software for Learning and Work" to our normal course offerings. This course has already been offered experimentally as special topics seminar. The course will explore the design of software systems that harmonize with how people learn and solve problems as individuals and groups. Students will develop knowledge and skills they can apply in their future roles as consumers, developers, and possibly researchers of software for learning and work. For each of various genres of software for learning and work, we read and critique papers on the design and evaluation of these systems, and try out and critique example systems. Students also engage in semester-long projects to design a learning or work-support system of their own.

An increased emphasis on HCI in general and software for learning in particular is critical in our department at this time, due to the ubiquitousness of human use of information technology in society in general and to our department's role in building high technology industry in Hawai'i.

Student Engagement in Research

Student participation in my research group, the Laboratory for Interactive Learning Technologies (http://lilt.ics.hawaii.edu) takes several forms, each of which will be enhanced by CAREER funding. Most obviously, CAREER funding will enable the long term funding of a student to assist with the research. Our department currently has an abundance of Master's students coupled with a lack of those committed to our new Ph.D. program. I will use CAREER funding of this position to actively recruit a Ph.D. student with interests in technologies for education into our program. In combination with pending RSI funding for Hawai'i Networked Learning Communities (also a 5 year proposal), CAREER funding will help address two problems: ensuring the survival of the department's nascent Ph.D. program, and keeping people around long enough to train them for this complex work in collaborative design, experimentation and use within educational communities.

I receive many requests from undergraduate and graduate students to conduct independent study projects. The interests and hence forms of participation generally takes two forms. A minority of these students has prior interest in human-computer interaction or education, and typically come with a project idea of their own. If their interests match my research objectives well, I supervise their projects while providing guidance in the design of their software and in experimental techniques for answering design questions, as appropriate. For example, I have supervised two students investigating collaborative technologies for distance education, and others developing educational applications in music education and history. Most students who approach me are not specifically interested in software for education, but rather are drawn to my laboratory's use of current technology (Java, JDBC, RMI, SQL databases, XML, etc.) and want to acquire these highly marketable skills. I have recently redesigned the software base for my research in a component manner, enabling students to extend this software incrementally with independent projects. These students work under the direct supervision of my lead programmer, from whom they acquire the technical expertise they seek. Presenting their work in weekly laboratory meetings, they soon discover that I provide them with user-oriented perspectives on their software designs that they have never encountered in their technical education. Thus, not only do these future information technology workers acquire technical skills, but they are also exposed to new ways of thinking about the human dimension of information systems.

Advisory Committee

I have formed an advisory committee to provide outside guidance for this work as well as to leverage existing collaborations. Some members have been chosen and agreed to serve; a few others could be added based on reviewer or NSF recommendations. The committee is formed in two parts: external advisors representing major relevant areas of research and practice, and local advisors who represent collaborating projects. Formal meetings would be logistically difficult due to schedules and Hawai'i's physical isolation. Hence most interaction with external advisors will be electronic or at conferences. I have budgeted for one trip per year for a visit by an external advisor, so that each advisor may observe the work firsthand at least once during the funded period.

External Advisors

The following persons have already agreed to serve as external advisors. If another member were added I would seek a person experienced with discussion tools or groupware for asynchronous distance collaboration (e.g., from the ALN or CMC communities).

Susan Goldman is a Professor in the Department of Psychology and Human Development and Co-Director of the Learning Technology Center (http://peabody.vanderbilt.edu/ctrs/ltc/) at Vanderbilt University. Her research interests concern the psychological processes whereby people understand and learn from text, discourse, and integrated media, and assessment models, especially alternative and formative assessment. She brings experience in discourse analysis methods for study of classroom interactions and discussions that take place in computer-based database and conferencing systems.

Kevin O'Neill is Assistant Professor of Education and Technology at Simon Fraser University in Burnaby, British Columbia. He brings many years experience in telementoring and knowledge-building environments, including work on CoVis and the Collaboratory Notebook at Northwestern, on CSILE at OISE, and on the design of online coaching tools for NetLearn at LRDC (during which I collaborated with him).

Jeremy Roschelle is a Research Scientist at SRI International's Center for Technology in Learning (http://www.sri.com/policy/ctl/). He brings an extensive background in educational software design, math and science education, collaborative learning, and video analysis methodology. For example, in his work at the Institute for Research on Learning, he investigated the conversational processes that enabled dyads to build shared understandings of scientific concepts. Dr. Roschelle managed software development for the SimCalc Project in its applications of advanced technologies, including 2D and 3D simulations, linked multiple representations, and dynamic editable graphs. He is presently co-director of the Community Tools Theme Team of the Center for Innovative Learning Technologies (http://www.cilt.org/).

Internal Advisors

The following persons are already collaborating with me on relevant projects and have agreed to serve as internal advisors.

Kim Bridges is Associate Professor in the Botany Department and Interim Assistant Director (half time) in charge of technology at Outreach College, both at the University of Hawai'i at Manoa. He is co-PI on PODS (http://www.botany.hawaii.edu/pods/), a DARPA grant with Edo Biagioni and Brian Chee (both of ICS) to develop communication modules that will deliver weather data and high-resolution images for areas with rare and endangered species, and is also developoing METAR Weather, an exploration into the data visualization and programming problems of supporting real-time weather displays compared to historical patterns. These technologies will be utilized by HNLC, for which Kim also serves as an advisor. Known as one of UH's most innovative adopters of technology for education, he also has prepared advance placement ICS course that is being taught in the state high schools via e-School (see Vicki Kajioka).

Vicki Kajioka is an Advanced Technology Specialist in Hawaii Department of Education (HDOE). Vicki is the Co-Director of the HDOE 1996 Technology Innovative Challenge Grant E-School (Electronic School, http://www.eschool.k12.hi.us/), and its successor E-Academy (http://e-academy.k12.hi.us/). She was the Co-Chairperson for the Goals 2000 Technology Panel that developed The Hawaii Connection: An Educational Technology Plan, 1995. Vicki is on the Tech Corps Hawaii Board of Directors, the Editorial Board for the Hawai'i Web & Internet News magazine and the Advisory Board of the Technology and Learning's School Tech Exposition & Conference.

Gordon Grau is Professor of Zoology and director of the Sea Grant College Program at the University of Hawai'i. Hawaii Sea Grant College Program is housed within the School of Ocean and Earth Science and Technology on the campus of the University of Hawaii at Manoa. The program is part of a nationwide network of 29 institutional programs of the NOAA National Sea Grant College Program, U.S. Department of Commerce, that promote the understanding, development, sustainable use and conservation of marine resources through university-based research, education, community outreach and communication services. As a zoologist, Grau continues work that explores biotechnology aimed at enhancing fish growth and development. As Sea Grant director, Grau is especially dedicated to attracting more undergraduates to the marine sciences and has outlined new educational initiatives with this in mind.

Timeline

Year 0. Prior to funding, I will conclude my LIS-funded research on representational bias with a study of distance collaboration. My students will begin to prepare the software for next year's studies in asynchronous collaborative learning. We will submit a proposal to RSI for five-year implementation of distance collaboration in Hawai'i DOE schools. As soon as funding notification is received, I will begin to recruit a Ph.D. student.

Year 1. Recruit HNLC K-12 teachers and scientists and begin collaborative design-work on design of knowledge representations and their use with disciplinary representations. Implement alternate Linked-CMC designs and evaluate them with usability studies. Develop and propose courses in Human-computer Interaction and Designing Usable Interfaces. Analyze the results of the previous year's LIS-funded studies and publish results.

Year 2. Conduct a comparative study of linked, parallel, and embedded CMC, with emphasis on implications for knowledge-building. Collaborating teachers and scientists begin classroom trials of the software, and develop associated instructional strategies and assessment methods. Propose course in Software for Learning and Work.

Year 3. Perform an in-depth analysis of data from the previous year's comparative study. Publish results. Based on what we learned from these studies and trial classroom use, begin construction of second generation of software. Initiate professional development program focusing on the use of collaborative representations to support asynchronous collaborative learning and for assessment.

Year 4. Conduct extended study of use of the knowledge-building environment in practice. Expand professional development activities. Develop a robust version suitable for widespread distribution. Conduct follow-up laboratory studies if new issues arise.

Year 5. Analysis and publication of results from continued field studies and follow-up laboratory study, if applicable. Dissemination of lessons, software, and materials.

References Cited

Baker, M. & Lund, K. (1997). Promoting reflective interactions in a CSCL environment. Journal of Computer Assisted Learning, 13, 175-193.

Bell, P. (1997, December). Using argument representations to make thinking visible for individuals and groups. In Proceedings of the 2nd International Computer Supported Collaborative Learning Conference (CSCL '97), (pp. 10-19). Toronto: University of Toronto.

Bordia, P. (1997). Face-to-face versus computer-mediated communication: A synthesis of the experimental literature. The Journal of Business Communication, 34(1), 99-120.

Brown, A. L. & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), Classroom Lessons: Integrating Cognitive Theory and Practice (pp. 229-270). Cambridge: MIT Press.

Chi, M. T. H., Bassok, M., Lewis, M., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. Cognitive Science, 13, 145-182.

Clark, H. H. & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. M. Levine and S. D. Teasley (Eds.), Perspectives on Socially Shared Cognition (pp. 127-149). American Psychological Association.

Collins, A. & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. Educational Psychologist, 28(1), 25-42.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Davis, J. R., & Huttenlocher, D. P. (1995). Shared annotation for cooperative learning. In Proceedings of the International Conference on Computer Supported Collaborative Learning (CSCL '95).

Guzdial, M. (1997, December). Information ecology of collaborations in educational settings: Influence of tool. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL '97), (pp. 83-90). Toronto: University of Toronto.

Guzdial, M., Hmelo, C., Hubscher, R., Nagel, K., Newstetter, W., Puntambekar, S., Shabo, A., Turns, J., & Kolodner, J. L. (1997, December). Integrating and guiding collaboration: Lessons learned in computer-supported collaborative learning research at Georgia Tech. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL '97) (pp. 91-100). Toronto: University of Toronto.

Herring, S. C. (1993). Gender and democracy in computer mediated communication. Electronic Journal of Communication, 3(2). http://www.cios.org/www/ejc/v3n293.htm

Herring, S.C. (1999, January). Interactive coherence in CMC. In Proceedings of the 32nd Hawai'i International Conference on the System Sciences (HICSS 32). (CD-ROM). Maui, Hawai'i: Institute of Electrical and Electronics Engineers, Inc. (IEEE).

Hewitt, J. (1997). Beyond threaded discourse. Paper presented at WebNet'97. Available: http://csile.oise.utoronto.ca/abstracts/ThreadedDiscourse.html

Hewitt, J., & Scardamalia, M. (1998). Design principles for the support of distributed processes. Educational Psychology Review, 10(1), 75-96.

Hoadley, C. M., & Enyedy, N. (1999, December). Between information and communication: Middle spaces in computer media for learning. In Proceedings of the 3rd International Conference on Computer Supported Collaborative Learning (CSCL '99). Stanford University.

Hoadley, C. M., His, S., & Berman, B. P. (1995). The multimedia forum kiosk and SpeakEasy. In P. Zellweger (Ed.), ACM Multimedia '95 (pp. 363-364). San Francisco, CA: ACM Press.

Koedinger, K. (1991). On the design of novel notations and actions to facilitate thinking and learning. In Proceedings of the International Conference on the Learning Sciences, (pp. 266-273). Charlottesville, VA: Association for the Advancement of Computing in Education.

Koedinger, K. R., Suthers, D. D., & Forbus, K. D. (1999). Component-based construction of a science learning space. International Journal of Artificial Intelligence in Education, 10, 292-313.

Kotovsky, K. and H. A. Simon (1990). What makes some problems really hard: Explorations in the problem space of difficulty. Cognitive Psychology, 22, 143-183.

Larkin, J. H. & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. Cognitive Science, 11(1), 65-99. 1987.

Lave, J. & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Mayadas, F. (1997, March). Asynchronous learning networks: A Sloan Foundation perspective. Journal of Asynchronous Learning Networks, 1(1). Online: http://www.aln.org/alnweb/journal/issue1/mayadas.htm

Novak, J. (1990). Concept mapping: A useful tool for science education. Journal of Research in Science Teaching, 27(10), 937-49.

Novick, L. R. & Hmelo, C. E. (1994). Transferring symbolic representations across nonisomorphic problems. Journal of Experimental Psychology: Learning, Memory, and Cognition, 20(6), 1296-1321.

O'Neill, D. K., & Gomez, L. M. (1994). The collaboratory notebook: A distributed knowledge-building environment for project-enhanced learning. In Proceedings of Ed-Media '94. Charlottesville, VA: Association for the Advancement of Computing in Education.

Perkins, D. N., Crismond, D., Simmons, R., & Unger, C. (1997). Inside understanding. In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), Software Goes to School: Teaching for Understanding with New Technologies, (pp. 70-87). New York: Oxford University Press.

Puntambekar, S., Nagel, K., Hübscher, R., Guzdial, M., & Kolodner, J. (1997, December). Intra-group and intergroup: An exploration of learning with complementary collaboration tools. In Proceedings of the 2nd International Computer Supported Collaborative Learning Conference (CSCL '97) (pp. 207-214). Toronto: University of Toronto.

Ranney, M., Schank, P., & Diehl, C. (1995). Competence versus performance in critical reasoning: Reducing the gap by using Convince Me. Psychology Teaching Review, 4 (2), 151-164.

Reader, W. (1997). Structuring argument: The role of constraint in the explication of scientific argument. Unpublished manuscript.

Reusser, K. (1993). Tutoring systems and pedagogical theory: Representational tools for understanding, planning, and reflection in problem solving. In S. P. Lajoie & S. J. Derry (Eds.), Computers as Cognitive Tools (pp. 143-177). Hillsdale, NJ: Lawrence Erlbaum Associates.

Roschelle, J. (1994, May). Designing for cognitive communication: Epistemic fidelity or mediating collaborative inquiry? The Arachnet Electronic Journal of Virtual Culture.

Roschelle, J., DiGiano, C., Koutlis, M., Repenning, A., Phillips, J., Jackiw, N. & Suthers, D. (1999). Developing education software components. Computer, 32(9), 50-58.

Russell, T. (1999). The no significant difference phenomenon. Available from Office of Instructional Telecommunications, North Carolina State University.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. The Journal of the Learning Sciences, 1(1), 37-68.

Scardamalia, M. & Bereiter, C. (1994). Computer support for knowledge building communities. Journal of the Learning Sciences, 3(3), 265-283.

Scardamalia, M., Bereiter, C., Brett, C., Burtis, P.J., Calhoun, C., & Smith Lea, N. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.

Slavin, R. E. (1990). Cooperative learning: Theory, research, and practice. Englewood Cliffs, NJ: Prentice-Hall.

Sloffer, S. J., B. Dueber, & T. M. Duffy. (1999, January). Using asynchronous conferencing to promote critical thinking: Two implementations in higher education. In Proceedings of the 32nd Hawai'i International Conference on the System Sciences (HICSS-32). (CD-ROM). Maui, Hawai'i: Institute of Electrical and Electronics Engineers, Inc. (IEEE).

Smolensky, P., Fox, B., King, R., & Lewis, C. (1987). Computer-aided reasoned discourse, or, how to argue with a computer. In R. Guindon (Ed.), Cognitive Science and Its Applications for Human-Computer Interaction (pp. 109-162). Hillsdale, NJ: Erlbaum.

Snir, J., Smith, C., & Grosslight, L. (1995). Conceptually enhanced simulations: A computer tool for science teaching. In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), Software Goes to School: Teaching for Understanding with New Technologies (pp. 106-129). New York: Oxford University Press.

Sproull, L. (1986). Reducing social context cues: Electronic mail in organizational communication. Management Science, 32, 1492-1512.

Stenning, K. & Oberlander, J. (1995). A cognitive theory of graphical and linguistic reasoning: Logic and implementation. Cognitive Science, 19(1), 97-140.

Suthers, D. D. (1999a, January). Representational support for collaborative inquiry. In Proceedings of the 32nd Hawai’i International Conference on the System Sciences (HICSS-32). (CD-ROM). Maui, Hawai'i: Institute of Electrical and Electronics Engineers, Inc. (IEEE). Available: http://lilt.ics.hawaii.edu/lilt/papers/hicss99.pdf.

Suthers, D. D. (1999b, July). Representational bias as guidance for learning interactions: A research agenda. To appear in Proceedings of the 9th World Conference on Artificial Intelligence in Education (AIED'97). Le Mans, France. PDF document available at http://lilt.ics.hawaii.edu/lilt/papers/SuthersAIED99.pdf

Suthers, D. D. (1999c, August). The effects of representational bias on collaborative inquiry. To appear in Proceedings of the 8th International Conference on Human-Computer Interaction**.** Munich Park Hilton: Munich, Germany.

Suthers, D. D. (1999d, August). Representational and advisory guidance for learning: Alternate roles for AI. To appear in Proceedings of the IASTED International Conference Artificial Intelligence and Soft Computing. Honolulu Hawai'i**.**

Suthers, D. D. (1999e, December). Effects of alternate representations of evidential relations on collaborative learning discourse. In Proceedings of the 3rd Conference on Computer Supported Collaborative Learning (CSCL '99). Stanford University.

Suthers, D. (2000, submitted). Towards a Systematic Study of Representational Guidance for Collaborative Learning Discourse. Journal of the Learning Sciences.

Suthers, D., Toth, E., and Weiner, A. (1997, December). An integrated approach to implementing collaborative inquiry in the classroom. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97), (pp. 272-279). Toronto: University of Toronto.

Suthers, D. and Weiner, A. (1995, October). Groupware for developing critical discussion skills. In Proceedings of the Computer Supported Collaborative Learning Conference (CSCL '95). Bloomington, Indiana.

Sweller, J., van Merrienboer, J.J.G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. Educational Psychology Review, 10(3), 251-296.

Tabak, I. & Reiser, B. J. (1997). Complementary roles of software-based scaffolding and teacher-student interactions in inquiry learning. In R. Hall, N. Miyake & N. Enyedy (Eds.), Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97), (pp. 289-298). Toronto: University of Toronto.

Toth, E., Suthers, D., & Lesgold, A. (2000, under review). Mapping to know: The effects of evidence maps and reflective assessment on scientific inquiry skills. Science Education.

Turoff, M., Hiltz, S. R., Bieber, M., Fjermestad, J., & Rana, A. (1999). Collaborative discourse structures in computer mediated group communications. Journal of Computer Mediated Communication, 4(4). Online: http://jcmc.huji.ac.il/

Wan, D., & Johnson, P. M. (1994, October). Experiences with CLARE: A Computer-supported collaborative learning environment. International Journal of Human-Computer Studies, 41, 851-879.

Webb, N. & Palincsar, A. (1996). Group processes in the classroom. In D. Berlmer & R. Calfee, (Eds.), Handbook of Educational Psychology. New York: Simon & Schuster Macmillian.

Wojahn, P.G., Neuwirth, C.M., & Bullock, B. (1998, April). Effects of interfaces for annotation on communication in a collaborative task. In Proceedings of the Conference on Human Factors in Computing Systems (CHI '98), (pp. 456-463). Los Angeles: ACM Press.

Zhang, J. (1997). The nature of external representations in problem solving. Cognitive Science, 21(2), 179-217.

Daniel Derwent Suthers

Dept. of Information and Computer Sciences
University of Hawai'i at Manoa
1680 East West Road, POST 303A
Honolulu, HI 96822

Voice: (808) 956-3890
Fax: (808) 956-3548
Email: suthers@hawaii.edu
Web: http://lilt.ics.hawaii.edu/

Professional Preparation

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

Graduate:
Northern Arizona University, Psychology, (no degree), 1982-1985.
University of Massachusetts, Computer Science, M.S. 1988.
University of Massachusetts, Computer Science, Ph.D, 1993.

Positions Held

1998-present: 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.

Publications Most Closely Related to Proposal

Suthers, D. (2000, submitted). Towards a Systematic Study of Representational Guidance for Collaborative Learning Discourse. Journal of the Learning Sciences.

Toth, E., Suthers, D., & Lesgold, A. (2000, under review). Mapping to know: The effects of evidence maps and reflective assessment on scientific inquiry skills. Science Education.

Suthers, D. D. (1999). Representational Support for Collaborative Inquiry. *Proceedings of the 32nd Hawai'i International Conference on the System Sciences (HICSS-32)*, January 5-8, 1999, Maui, Hawai'i (CD-ROM), Institute of Electrical and Electronics Engineers, Inc. (IEEE). Available: http://lilt.ics.hawaii.edu/lilt/papers/SuthersAIED99.pdf

Suthers, D., Toth, E., and Weiner, A. (1997, December). An integrated approach to implementing collaborative inquiry in the classroom. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97), (pp. 272-279). Toronto: University of Toronto.

Suthers, D. & Weiner, A. (1995). Groupware for Developing Critical Discussion Skills. In John L. Schnase and Edward L. Cunnius, Eds. Proceedings of CSCL '95, the First International Conference on Computer Support for Collaborative Learning. Oct. 17-20, 1995. Indiana U. Bloomington, IN. Mahwah, NJ: Lawrence Erlbaum Associates, pages 341-348. Available: http://www-cscl95.indiana.edu/cscl95/suthers.html

Other Publications

Koedinger, K. R., Suthers, D. D., & Forbus, K. D. (1999). Component-based construction of a science learning space. International Journal of Artificial Intelligence in Education, 10, 292-313.

Roschelle, J., DiGiano, C., Koutlis, M., Repenning, A., Phillips, J., Jackiw, N. & Suthers, D. (1999). Developing education software components. IEEE Computer, 32(9), 50-58.

Paolucci, M., Suthers, D. & Weiner, A. (1996). Automated Advice-Giving Strategies for Scientific Inquiry. In *Intelligent Tutoring Systems: Third International Conference, ITS'96*, (pp. 372-381). Berlin: Springer-Verlag.

Suthers, D. (1993). Sequencing explanations to enhance communicative functionality. In *Proceedings of the 15th Annual Meeting of the Cognitive Science Society*, (pp. 988-993). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Suthers, D. (1991). A Task-Appropriate Hybrid Architecture for Explanation. *Computational Intelligence. 7* (3).

Synergistic Activities

Award for Collaborative Research
Received the Center for Innovations in Learning Technologies (CILT) "Spotlight" award, Community Tools area, Awarded at the annual American Education Research Association meeting. This was for collaborative research on a CILT seed grant titled "Interoperable Components for Shared Active Representations": Daniel Suthers (U. Hawai'i,

PI); Cindy Hmelo (Rutgers University), Patricia Schank (SRI International), Nicholas Jackiw (Keypress), and Bill Sandoval (UCLA) along with many others. Presently I am involved in a related CILT-funded project, "Designing Knowledge Representations for Learning Epistemic Practices of Science," William A. Sandoval (PI, UCLA), Philip Bell (U. Washington), Elaine Coleman (SRI), Noel Enyedy (Berkeley), Daniel Suthers (U. Hawai'i at Manoa).

Asynchronous Learning Networks
Co-PI on the University of Hawai'i's Asynchronous Learning Networks (ALN) initiative, and departmental lead for development of ALN versions of our B.A. and M.S. degrees. This work is intended to serve an increasingly diverse population of learners, some of whom cannot attend scheduled class meetings due to work constraints, parenthood, or our island geography, as well as to enhance options for on-campus students.

Course Development
These courses were taught as special topics seminars, and will be proposed for inclusion in the regular curriculum.

Software for Learning and Work: Examines the design of software systems that harmonize with how people learn and solve problems as individuals and in groups. Surveys several genres of software for learning and work. Students also engage in semester-long projects to design a learning or work-support system of their own. This course is intended to support rapid integration of recent research results into the curriculum. It was offered at the graduate level in face to face meetings and at the undergraduate level through Asynchronous Learning Networks.

Designing Usable Interfaces: Explores software development methodologies that integrate users into the design process early and often, and utilize explicit models of user roles and tasks which are then used to derive models of the software interface. Students develop and evaluate an interactive application of their own. This course was offered simultaneously though face to face and ALN modes to explore how we can expand our ALN offerings without reducing campus-based courses.

Book Editorship
Coediting "Arguing to Learn: Confronting Cognitions in Computer-Supported Collaborative Learning Environments," Jerry Andriessen, Michael Baker, Daniel Suthers, editors. Computer-Supported Collaborative Learning Series. Series Editor: Pierre Dillenbourg. This book is about the processes by which students and teachers can learn by confronting their cognitions within Computer-Supported Collaborative Learning environments (CSCL, computer-based learning environments that are designed to be used for group work). It focuses on the processes and medium of collaborative learning through argumentation. Publication by Kluwer Academic expected in 2001.

Workshops and Conference Tracks
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. Also organized a workshop on "Collaborative Representations: Analyzing Learning Interactions." Participants shared video data of students and teachers using representationally rich collaborative learning environments, and shared techniques for the study of this data by demonstrating their analysis techniques.

Collaborators & Other Affiliations

Collaborators within the past 48 months:
Jerry Andriessen (Utrecht), Michael Baker (CNRS & Université Lumière), Philip Bell (U. Washington), Frank Belz (TRW), Lynn Churchill (U. Montana), Elaine Coleman (SRI), Noel Enyedy (Berkeley), Ken Forbus (Northwestern U.), Violet Harada (U. Hawai'i), Cindy Hmelo (Rutgers), Neil Jacobstein (Teknowledge), Nicholas Jackiw (Keypress), Vicki Kajioka (Hawai'i DOE), Sandra Katz (U. Pittsburgh), Victor Kobayoshi (U. Hawai'i), Ken Koedinger (CMU), Alan Lesgold (U. Pittsburgh), David Luckham (Stanford U.), Jaishree Odin (U. Hawai'i), Massimo Paolucci (CMU), Lauren Resnick (U. Pittsburgh), Jeremy Roschelle (SRI), Steve Ritter (CMU), Bill Sandoval, (UCLA), Patricia Schank (SRI International), David Thomas (Montana State U.), Eva Toth (CMU), Arlene Weiner (formerly U. Pittsburgh), Tom Wheeler (ARMY CECOM), Beverly Woolf (U. Massachusetts).

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. Theses in progress: Angeles Constantino (ITESM, Monterrey Mexico), Amy Soller (U. Pittsburgh). Master's Thesis awarded: Bo Yang (University of Hawai'i). Postdoctoral: Christopher Hundhausen (University of Hawai'i).

Facilities

Laboratory:

The Department of Information and Computer Sciences occupies an entire floor of the new POST building on the University of Hawai'i Manoa campus. Designed for computer science research, this building provides more than adequate space and infrastructure.

The Laboratory for Interactive Learning Technologies currently occupies 3 offices, 1 general meeting area, a programmer workspace, and a small laboratory with computer and video equipment for the study of human-computer interaction. The video equipment needs to be upgraded and replicated for asynchronous collaboration studies: this is included in the budget. The other facilities will be adequate for hosting small meetings with collaborating teachers and scientists.

Clinical:

Not applicable.

Animal:

Not applicable.

Computer:

The Department of Information and Computer Sciences of the University of Hawai'i has 38 SUN SPARCstations (mostly 20's, 10's, and 5's), over 100 Pentium-class PCs, about 30 Macintosh computers, 9 laser printers, and various hypermedia devices.

The Laboratory for Interactive Learning Technologies itself has 6 Pentium-class PCs, 2 Macintoshes, one Solaris server with tape backup, and two Solaris workstations. The Solaris server will be adequate for the present project. It was necessary to budget for two PCs to be reserved for asynchronous collaboration studies because the others are in use by staff, and we need to upgrade our equipment for the new work.

Office:

Office space for the principal investigator and graduate student will be provided in the POST building for the duration of the study.

Major Equipment:

The Belvedere server will be run on an existing Solaris machine, providing automated data recording capabilities, and mediating communications in the distance collaboration studies.

Other Resources:

Collaborating teachers will also be able to draw upon Hawai'i DOE's E-School / E-Academy computer facilities.

University of Hawai'i at Mānoa
Department of Information and Computer Sciences
1680 East-West Road • Honolulu, Hawaii 96822

July 24, 2000

Departmental Endorsement and Certifications

The mission of the Department of Information and Computer Sciences is to provide the finest education and research, and to be an effective catalyst for the growth of entrepreneurial, high technology, software-intensive industries in the State of Hawai'i. Education at all levels and in all manifestations is at the core of the mission of our department. Research on technology for education touches on more of our concerns than any other research area in our department. Since we are a state of many geographically separated islands, we have critical need for innovative use of educational technology to address the needs of isolated communities. Our partnership with the Hawai'i Department of Education (HDOE, the statewide school district) positions ICS as one of the leading organizations statewide in the rejuvenation of public education. The Hawai'i Networked Learning Communities initiative, described previously in this proposal, was initiated directly as a collaboration between HDOE and ICS. We are also offering ICS courses for advanced placement high school students taught though HDOE's e-School, relying heavily on educational technologies such as Asynchronous Learning Networks. Similarly, our partnership with the University of Hawaii's Outreach College in developing a system-wide Asynchronous Learning Network for delivery of UH degrees positions ICS as the leading department in the University system preparing for a strategically important component of the future of university education.

Clearly, Dr. Suthers' current and planned research on advanced technologies for asynchronous collaborative learning and its use in K-12 and university settings is of utmost importance for the educational goals and growth of our department. The department will provide adequate lab space and technical administrative support for this activity. Release time commensurate with the research activity and consistent with departmental and university policy will be provided.

Daniel D. Suthers meets the CAREER eligibility criteria as described in Section III.A of NSF 00-89. He is in his first tenure track appointment and is untenured. His appointment in the College of Natural Sciences at the University of Hawaii at Manoa started on August 1, 1998. He received his first doctorate degree in February 1993. He has not previously received an NSF PECASE or CAREER award.

I have read and I wholeheartedly endorse this Career Development Plan.

Stephen Y. Itoga

Professor and Chair, Department of Information and Computer Sciences
College of Natural Sciences, University of Hawaii at Manoa

Monday, July 24, 2000

BENJAMIN J. CAYETANO
GOVERNOR

PAUL G. LeMAHIEU, Ph.D.
SUPERINTENDENT

STATE OF HAWAII
DEPARTMENT OF EDUCATION
P.O. BOX 2360
HONOLULU, HAWAII 96804

DIVISION OF LEARNER, TEACHER, AND SCHOOL SUPPORT

July 24, 2000

Dr. Elizabeth VanderPutten
CAREER Directorate Contact
Div. of Research, Evaluation & Communication (REC)
Directorate for Education and Human Resources (EHR)

Dear Dr. VanderPutten:

Hawai'i's small rural schools are challenged to offer a diversity of science, math and technology courses so essential to successful careers in today's world. Our unique island geography mandates a central role for distance learning technology in solving this problem. In response to this need we have made great strides in implementing a new concept of schooling that moves toward digital literacy through a systematic, well-planned, diversity/equity-driven model of educational transformation.

Our E-School and Magnet Electronic Academy (E-Academy), supported by USDOE Technology Innovation Challenge Grants, establish virtual and on-site magnet school centers grounded in solid educational pedagogy, enhanced by model projects and staff development modules, imbedded in whole communities and geared to teachers having unlimited access to professional development. As part of this work, the Advanced Technology Research (ATR) Office, within my division, has developed an innovative program called Technology and Telecommunications for Teachers (T3), designed to prepare school leaders who will infuse appropriate technology into instruction to enhance student learning. T3 participants learn to apply a variety of technologies, and receive professional development credits for their work. Through this program we have formed a community of expert teachers who mentor others in the use of technology.

As one of the instigators of the Hawai'i Networked Learning Communities initiative, Dr. Suthers is playing a central role in the development of collaborations between the Hawai'i Department of Education and the University of Hawai'i. Over the past year my staff and I have been working closely with Dr. Suthers on this initiative.

Dr. Suthers' proposed CAREER work will support students' online collaborative learning with an innovative integration of discussion tools with knowledge mapping tools and other visual media. Since this work will dovetail closely with our work in HNLC and E-Academy, my staff and I will assist Dr. Suthers in recruiting collaborators from the T3 community of expert teachers. Dr. Suthers plans to pay these teachers honoraria to help ensure the pedagogical soundness of the new technology and collaborate in developing instructional and assessment strategies for its use. As the technology becomes ready for use in classrooms and E-Academy, we will provide other teachers in the T3 program with the opportunity to obtain professional development credits for their work in adopting this technology to serve standards-based systemic reform in their classrooms.

We look forward to working with Dr. Suthers in the CAREER project and ask that serious consideration be given his proposal.

Sincerely,

Diana K. Oshiro
Assistant Superintendent