MIND BRIDGES: A Distributed, Multimedia Learning Environment for Collaborative Knowledge Building

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Abstract: Recent work in the fields of cognition and education has drawn attention to the benefits of attempting to understand cognition from a social constructivist viewpoint and facilitating students’ learning through computer-supported collaboration. This paper outlines the rationale for grounding cognitive and educational research on a social foundation. This rationale, in turn, provides the motivation for developing MIND BRIDGES, a computer-based, distributed, multimedia learning environment for collaborative knowledge building. MIND BRIDGES features media-rich support for students’ articulations in both a local area network computing environment as well as a client-server computing environment using TCP/IP. The current version of the system is described by means of an illustrative example so as to suggest the kind of collaborative knowledge building that students can engage in through the use of MIND BRIDGES.

INTRODUCTION

Cognitivistic and individualistic approaches to trying to understand human mental functioning have been on the wane for the past several years (see, for example, Still & Costall, 1991; Wertsch, 1985). Concomitant with this decline, we have witnessed the rise of situated and developmental approaches to understanding cognition (Brown, Collins, & Duguid, 1989; Clancey, 1991; Clancey & Roschelle, 1991; Jost, 1995; Wozniak & Fischer, 1993). In the context of this milieu, social constructivism is a viewpoint that increasingly dominates the fields of education and the learning sciences (Prawat & Floden, 1994). Bredo (1994) provides a penetrating analysis of the underlying paradigm shift that is taking place.

Social constructivism is based on a contextualist world view, one in which acts or events unfold in context. From this perspective, the main task of intelligent human effort is to make stability of meaning prevail over the instability of unfolding real-world events (Dewey, 1925/1981). Knowledge and knowing result from processes of social interchange and
interaction with the environment. Knowledge acquisition does not entail absorbing *truth*, as defined by some outside criteria, into one’s mind. Rather, it is the direct consequence of social interaction (Rowe, 1991). Things that individuals perceive and experience are mediated by their own interpretation of surrounding phenomena. These interpretations are constrained by the interactions of individuals with other people as well as by their personal goals.

Given the context above, the goal of instruction is to nurture the ongoing processes by which learners ordinarily come to understand the world in which they live. The role of teaching shifts from seeking to maximize the communication of fixed content or skills to one in which students are led to construct interpretations, appreciate multiple perspectives, develop and defend their own positions while recognizing the views of others, and to become aware of and be able to manipulate the social process of knowledge construction itself (Knuth & Cunningham, 1993). These processes of human learning inherently entail social couplings based in language. Human learning is, in a very real sense, human languaging: the exchange of conversation and dialog.

Consequently, human learning is best understood as a process of developmental socialization (Jost, 1995). This idea is a common thread reflected in the work of Vygotsky (1978), Mead (1934), Dewey (1925/1981), and Wittgenstein (1953). Wertsch (1979; 1985), for example, argues that for both Vygotsky and Wittgenstein, socialization in general and social interaction in particular play a significant role in their views of human cognitive development because individuals come to see the world by representing it socially—through conventional means, such as language, and for social purposes, such as communication. The speaking of language requires a variety of supporting practices and behaviors: a form of life. Jost (1995) argues that for Wittgenstein, “the language-game creates and sustains the representative relationships between language and reality” (p. 14). Without the context of
social interaction and cultural norms which regulate the interaction, language-games would be meaningless.

**COLLABORATIVE KNOWLEDGE BUILDING ENVIRONMENTS**

The central role of language, as a vehicle through which a socialized form of learning occurs, has led us to develop *MIND BRIDGES*, a tool intended to facilitate and augment this kind of learning process. In earlier papers (Chee, 1994; 1995), we reported on two previous versions of *MIND BRIDGES*. This paper describes our third and current implementation of the *MIND BRIDGES* collaborative learning environment, together with networking and interface enhancements.

*MIND BRIDGES* is a distributed learning environment designed to support students’ meaning construction through shared discourse. It allows students to generate a communal knowledge base over a network of Apple Macintosh computers. Using the system, students can enter questions, findings, ideas, and explanations in all curriculum areas in the form of *messages*. The *MIND BRIDGES* network can be either a local area network or a TCP/IP-based client-server network. With the TCP/IP version, *MIND BRIDGES* is freed from the constraints of a local area network setup. It can support inter-school as well as inter-nation networking. Geographical separation no longer matters. Students can begin to truly benefit from the experience of learning together apart (Kaye, 1992).

The user interface of *MIND BRIDGES* has evolved significantly over its different versions. One limitation of the first version of *MIND BRIDGES* was that different media types were shown in *separate* windows. Hence, a message consisted of a loose collection of media types (text, graphics, sound, and movie), with the possibility of having multiple instances of any media type. This property of the interface made it difficult for students to express their ideas in a natural, sequential flow. *MIND BRIDGES* now features a *single* message document that integrates instances of media types in sequence; that is, *MIND BRIDGES* now supports
integrated multimedia documents. *MIND BRIDGES* also now allows students to record digital movies by controlling a videocamera from within the program. This functionality is particularly useful because it allows students to point a videocamera at themselves and record themselves speaking. Alternatively, they can zoom in on some artifact while providing ongoing commentary. This form of inter-student communication can be extremely powerful and compelling.

The development of *MIND BRIDGES* follows in the spirit of CSILE, a computer-supported intentional learning environment, that allows school children to engage in building knowledge together through the use of networked computers (Scardamalia & Bereiter, 1989; Scardamalia & Bereiter, 1992a). Using such an environment, students learn to pursue knowledge related to goals, to relate new knowledge to old, to monitor understanding, to infer unstated information, and to review, reorganize, and reconsider their own knowledge (Scardamalia & Bereiter, 1989). Scardamalia & Bereiter have demonstrated how learning environments of this kind can give rise to qualitative differences in learning. In particular, children learn to ask educationally productive questions that manifest a shift from text-based questions to knowledge-based questions (Scardamalia & Bereiter, 1991; Scardamalia & Bereiter, 1992b). Scardamalia et al. (1992) document the effects of CSILE use on the quantity of writing, depth of explanation, knowledge quality, question asking, and achievement test scores in a Canadian classroom context.

The development of *MIND BRIDGES* is also rooted in the vision of distributed multimedia learning environments as instruments for transformative communications (Pea, 1994; Pea & Gomez, 1992). This vision is predicated upon four fundamental shifts in perspective with respect to learning and education. First, knowledge is viewed as being socially constructed through action, communication, and reflection on the part of learners; learners are not simply receivers of knowledge-as-facts. Second, learning is viewed as situated in communities of practice rather than occurring as part of decontextualized classroom activities. Third, focus is placed on authentic tasks and using educational materials that enable instructors to begin
with what learners already know. Fourth, teaching is viewed as a process of modeling expert practice and promoting learning conversations that allow students to negotiate meanings rather than as simply an activity of delivering curricula (Pea & Gomez, 1992). *Mind Bridges* is a collaborative knowledge building tool that is consistent with the view of learning espoused by Pea & Gomez. The name *Mind Bridges* is intended to suggest that the purpose of the distributed learning environment is to function as a bridge between the minds of students. The traversal of this bridge is realized through transformative communications: assertions and negotiations of meaning that promote conceptual change. *Mind Bridges* provides the infrastructure for meaning-making discourse. It does so in a media-rich way by allowing students to make use of text, graphics, sound, and digitized video in their articulation of ideas. Like Pea (1994), we recognize the importance of both social and material embeddedness of meaning making in human interaction. Thus, the use of *Mind Bridges* should always go hand-in-hand with some instantiated learning activity that provides the necessary experiential grounding for meaning making.

**ARCHITECTURE OF MIND BRIDGES**

*Mind Bridges* is divided into distinct *environments* for different categories of knowledge and distinct *thematic spaces* differentiated according to topic. Students can move from one environment to another while remaining in the same thematic space, or they may remain within a given environment and move through different thematic spaces. There are two types of messages in *Mind Bridges*: private and public. Private messages are meant to be seen and read only by an individual student. Public messages are accessible by all users of the system.

*Mind Bridges* consists of six different knowledge-building environments. The *Overview* environment provides a global perspective of the thematic space selected. It typically contains messages that address the question *WHAT*. Messages entered may be introductions to or summaries of some particular topic. The *Explanation* environment contains messages directed at promoting deeper understanding of a particular topic. The environment deals principally
with questions and comments that address the question WHY. It is ideally suited to articulating and reflecting upon students’ evolving theories of natural phenomena.

The Processes environment contains messages that focus on explaining how “things” work. These “things” include but are not restricted to machines and other man-made artifacts, physical theories, and biological processes. Consequently, this environment contains comments and questions that address the question HOW. Animation, video clips, and other multimedia illustrations can be incorporated to support students’ expression and presentation of how things work. The Application environment features illustrations of real-world instances of the selected topic. The use of digitized video clips is particularly suited to illustrating the application of a selected topic in a realistic context. Relating concepts and theories to examples in the Application environment is intended to help enhance students’ understanding of the particular topic being investigated.

The Conjecture environment allows students to send messages that are of a speculative nature. This environment collects questions of a WHAT IF nature. The Location or Time environment focuses on messages where the place of an event’s occurrence or the time of its occurrence is particularly salient. Locations can be either terrestrial or extra-terrestrial; the time element can relate to the past, present, or future. Hence, this environment addresses questions that deal with WHERE and WHEN.

By requiring students to explicitly specify the environments that apply to any particular message they compose, it is hoped that students will be led to reflect upon the nature of the knowledge that they are contributing to the communal knowledge base. Thematic spaces, on the other hand, are used to segregate the MIND BRIDGES knowledge base into distinct domain areas; for example, physics, chemistry, biology, literature, and geography. Clearly, the applicability of the six available environments will vary with the thematic space chosen. Thus, an environment such as Process will be highly pertinent in the Physics thematic space, but barely applicable in the Literature thematic space.
USING MIND BRIDGES

To illustrate the current version of MIND BRIDGES, we employ a hypothetical example to show how two students might use the learning environment to engage in collaborative knowledge building.

The scenario

Suppose that there are two students, Edwin Chan and Jason Lee, who are part of a collaborative learning classroom. Suppose further that the class teacher has been dealing with the subject of the planets in the solar system. She has asked the class to find out more about the topic and to engage in discussion amongst themselves on the topic so that after a fortnight, each student can make a 10-minute presentation to the class on the topic.

In a learning context where students are technologically literate and where they have Internet access, the introduction of a system like MIND BRIDGES will allow teachers to engage students in a rich, socialized learning experience.

An illustrative walkthrough

Let us say that Edwin browses through the World Wide Web (WWW) and discovers an attractive movie of the space probe Galileo flying past the planet Saturn. He downloads this resource with the intention of sharing it with his classmates. Edwin then boots up a computer that operates as a MIND BRIDGES client in a client–server computing environment. On starting up the MIND BRIDGES application, a startup movie is played. The system then presents Edwin with a login panel. Edwin types in his name and password. The system performs authentication checks to ensure that Edwin is a bona fide user before presenting him with its Main Menu (see Figure 1). Three choices are available: Send Messages, Read Messages, and Find Messages.
Given that Edwin wishes to share his thoughts on the movie that he has found, he clicks on the Send Messages button. The Send Message window appears, allowing him to create a message. The system automatically inserts the current date and time. It also enters Edwin’s name as the message sender and, as a default, addresses the message to be created to the Public Database.

To begin, Edwin types the subject of his message: “Is the planet Saturn habitable?” As Edwin has a conjecture on his mind, he selects the Conjecture environment by placing a checkmark against that environment. Then, Edwin clicks on the Thematic Space area. A window pops up allowing him to select an appropriate thematic space for his message. This window shows the thematic spaces currently available. It also allows the creation of new thematic spaces should existing ones not be suitable. Edwin chooses the thematic space Astronomy. With the environment and thematic space set, Edwin proceeds to import his movie into the multimedia message document. He does so by clicking on the import movie icon in the tool palette. A file dialog appears, allowing him to import his movie of Saturn. Edwin proceeds to click on the text creation tool (denoted by an icon of a pencil against a piece of paper) in the tool palette. He then types the text of his message. Finally, Edwin clicks on the Keywords area to define suitable keywords for indexing his message. A Choice of Keywords dialog appears. Edwin chooses the keywords planets and solar system. At this juncture, message composition is complete, and the system state is depicted in Figure 2. Edwin then clicks on the button Send and the message is sent to the server computer. In a moment, the system notifies Edwin that his message has been sent.
Suppose now that the student Jason Lee logs into MIND BRIDGES and decides to find out what conjectures have been made by his classmates on the subject Astronomy. Jason selects the Read Messages button from the Main Menu, and he is presented with the Read Public Messages window. Jason selects the Conjecture environment and the Astronomy thematic space. He then clicks on the button Retrieve. In a short while, the system displays all messages found within the Conjecture environment of the Astronomy thematic space (see Figure 3).

There is only one message in this instance: the message sent by Edwin Chan. Jason double-clicks on the message description. The system retrieves Edwin’s message from the server and displays it (see Figure 4). Horizontal arrowhead buttons (shown in dark gray) that support traversal through multiple messages are available in the Read Public Message interface. Thus, if two messages had been retrieved instead, clicking on the dark gray button that points to the right will cause the second message to be retrieved and displayed.

Suppose now that Jason has his own contribution to make to the knowledge building process. He has also been browsing the WWW and has discovered information related to the Shoemaker-Levy comet hitting the planet Jupiter. He has taken a screen snapshot of his favorite comet impact picture and decides that this is worth sharing with his classmates. Jason clicks on the Respond button (see Figure 4) to respond to Edwin’s message. (If Jason had clicked on the Reply button instead, his message would be sent to Edwin, not to the public database.) A Send Message window appears with Edwin’s contribution marked by bullet
symbols on the left-hand side. The bullets are used to distinguish content from the original message. Jason imports his Shoemaker-Levy graphic, retains one paragraph of Edwin’s contribution, and types his own comment regarding Saturn (see Figure 5). Jason clicks on the Send button to send the message to the Public Database. Note that in this instance, Jason’s message will form part of a thread of messages that originated with Edwin’s question: “Is the planet Saturn habitable?”

When threaded messages become available as a result of students responding to one another’s messages, the retrieved message list when a student selects Read Message will contain messages with a “+” symbol in the left margin of the message list. This symbol denotes the existence of a message thread (see Figure 6). In our example, the top message is the first message sent by Edwin to the Astronomy thematic space. By clicking on this message in the message list, the button Show Threads becomes active. Selecting this button causes the available threads to be displayed (see Figure 7).

If a student selects a threaded message and clicks on the button Read, that message will be retrieved from the database and displayed for reading. When one or more threads exist for a given message, students can traverse through the threads by clicking on the vertical arrowhead buttons shown in light gray (see Figure 4).
Where *MIND BRIDGES* is used in a classroom context, there would, of course, be more students than the two whom we have dealt with in our example. As students engage in sending messages and responding to one another’s messages, a rich knowledge base that documents their evolving thinking in different subject areas builds up rapidly. The content of the knowledge base becomes a resource for further articulation and commentary.

**Other features**

Suppose now that a third student, Petrina Tan, logs into *MIND BRIDGES*. Petrina has a special interest in things related to *planets*. To find out what information *MIND BRIDGES* contains about this topic, she clicks on the *Find Messages* button in the *Main Menu*. A window appears allowing her to formulate her search of the database for messages indexed by the keyword *planets*. Message searches can be constrained by specifying up to two keywords and using the operators *or*, *and*, and *not*. Petrina decides to restrict her search to the *Conjecture* environment in the thematic space *Astronomy*. She selects the appropriate environment and thematic space and clicks on the button *Retrieve*.

*MIND BRIDGES* executes a search of the communal knowledge base and lists all messages satisfying the search criteria (see Figure 8). Three messages have been found. Petrina can read any message by selecting it and clicking on the *Read* button. The selected message will be displayed for reading in the usual manner. In this manner, messages from the *Public Database* can be retrieved using keyword searches. While keyword-based searches may appear simple and relatively inflexible, they work well in practice. Until good indexing algorithms for free-format content become available, it seems reasonable to make use of keyword indexing.

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Although our example revolving around Edwin and Jason did not include any instance of messages incorporating sound or digitized video, *MIND BRIDGES* is capable of including sound and video media. With the Macintosh’s in-built facility to record sounds directly, no special hardware is required. Audio recordings of relevant sounds (for example, students’ voice recordings) can be conveniently made and easily incorporated into messages. Alternatively, custom sounds, such as sounds from nature, can be recorded to tape, digitized, and imported directly into *MIND BRIDGES*. In addition, *MIND BRIDGES* provides a software interface that allows students to connect a videocamera and create digital movies. Students can point a videocamera at themselves and record themselves speaking (see Figure 9), or they can zoom in on some artifact while providing ongoing commentary. In this manner, media-rich articulations for collaborative knowledge building are supported by *MIND BRIDGES*. Import functions are available for all four media types. In addition, *MIND BRIDGES* provides editing tools (for example, cut object, copy object, paste object, and clear object) so that students can refine their multimedia articulations to their complete satisfaction. These tools are accessible from the *Edit* menu as well as from the horizontal tool bar in the *MIND BRIDGES Send Message* interface.

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Finally, we have designed *MIND BRIDGES* such that, in the TCP/IP version, the establishment of TCP/IP connections between computers is transparent to users. Required IP connection addresses are preconfigured by the *MIND BRIDGES* system administrator (see Figure 10). In this way, when a student launches *MIND BRIDGES* from a client computer, a connection is automatically established with the server computer, and use of the system proceeds in the normal way. The only difference that students are likely to notice is longer delays in the
sending and retrieval of messages. Students are shielded from the complexity associated with domain name systems and IP dot addresses.

CONCLUSION

In this paper, we have discussed the motivation for developing collaborative knowledge building systems. We have illustrated how MIND BRIDGES allows students to engage in collaborative knowledge construction through the creation of integrated multimedia documents that support the expressive richness of their articulations. The distributed, client–server nature of the system allows students to engage in learning together while apart. Use of the TCP/IP version of MIND BRIDGES allows students to engage in inter-school learning experiences that may transcend national boundaries. Thus, learning can become both collaborative as well as international. Students can begin to experience the added dimension of sociocultural diversity with remote co-learners, thereby enriching learning.

Our current version of MIND BRIDGES runs only on Macintosh computers. A port of MIND BRIDGES to the Windows platform has been initiated, and we expect to have a local area network of MIND BRIDGES for Windows soon. The development of a TCP/IP Windows version is planned, but this will take more time to complete because we need to develop the TCP/IP connectivity layer of the software ourselves.

MIND BRIDGES is currently deployed at two separate schools where we are using it as part of an empirical study of inter-school collaborative learning in the domain of English Literature. One school is a boys’ school and the other is a girls’ school. Several classes of students are
involved. Some students are using MIND BRIDGES for shared articulations in the domain of poetry while others are using it to study Shakespeare’s Macbeth. We are tracking evidence of students’ conceptual change and growth in their appreciation of Literature. We hope to present results of these studies in due course.

References


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Figure 1 The main menu of MIND BRIDGES
Figure 2 A composed message in *MIND BRIDGES*, ready to be sent
Figure 3  Displaying the retrieved messages list
Figure 4 Reading a retrieved message
Figure 5 Responding to a public message

I was browsing through the WWW and came across this splendid movie of a spacecraft flying by Saturn. Wow!

Saturn sure looks intriguing. Those bands whirling around the planet! Do you think humans could pass through safely?

Anyway, look at what I found on the WWW! This picture of the Shoemaker-Levy comet hitting Jupiter in 1994 is awesome. The planet sure looks fiery hot.
Figure 6 First message with indicator that it is a threaded message
Figure 7 Message with threads shown
Figure 8  Results from executing a Find Message
Figure 9  Recording a live video message
Figure 10 Configuring the MacTCP settings