The role of a wiki in supporting group cognition

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Abstract

The Virtual Math Teams (VMT) environment has recently integrated a wiki component into its text chat and shared whiteboard system. The wiki component serves a number of purposes, such as summarizing synchronous small-group interactions and sharing the results among groups in a knowledge-building community.

We are exploring ways of integrating activities in the different work-space components, such as automating the posting of text from the whiteboard to a wiki page associated with the chat room, allowing collaborative browsing and editing of the wiki from the whiteboard, referencing elements of the wiki from the chat, and facilitating seamless navigation among the components. The wiki pages for chat rooms are automatically linked via categories within a "wikipedia" for the specific domain of interest to the knowledge-building community.

The VMT system including wiki is currently being used for middle-school, high-school and junior college math students, for masters-level information science students and for research teams. Logs of VMT system usage are analyzed in considerable detail. To date, over 50 publications have resulted from research on the VMT system, although the effectiveness of the wiki component has not yet been analyzed. The VMT project is part of an effort to investigate group cognition—the accomplishment of problem-solving and knowledge-building tasks by small groups, particularly in online, distributed contexts.

Designing for Groups and Group Cognition

This paper is about how to design software to support group cognition, that is to open a communication space or medium for groups of people to solve problems together and to build shared knowledge. To reflect on the software design process, we build on the approach of human-computer interaction (HCI). HCI as a field has historically been oriented largely toward the relationship between the *individual* computer user and the interface of computer software. Classic HCI studies investigated the effects of different designs of desktop software upon individuals using the software. The theory of HCI was, accordingly, closely aligned with the science of individual psychology. For reasons to be discussed in this paper, we propose to look at human-*human* interaction that is mediated by computer software and by the networking of computers. The software is here seen largely as a technological communication medium which both supports and constrains interaction among groups of users. More precisely, our concern is with the small-group interaction itself, that is, the group processes, rather than the interaction of one individual as such with other individuals in the group. Conceptually and methodologically, this involves a shift from the psychology of mental processes, representations and conceptual change of individuals to the largely linguistic *interactions* of small groups.

The proposed shift entails a shift from the education of individual minds to knowledge building within groups. The issue changes from tracing effects on students of the transfer of factual knowledge from authorized sources (teachers, textbooks, drill software) to understanding how groups build and share knowledge. This new focus is sometimes termed *collaborative learning*, which includes both how groups increase knowledge and how the individuals within the groups learn concomitantly. We actually prefer the term *knowledge building* to either “education” or “learning”. Our preference is partially because the terms “education” and “learning” tend to be closely associated with traditional institutions of schooling and with psychological theories of individual minds. It is also due to the fact that one can observe the building of knowledge in products of group work, such as discourse, theory statements and documents; knowledge building can more easily be operationalized and studied.

The Potential Contribution of HCI to Education

The History of Computer Support for Learning

Starting even before personal computers were developed and long before they were networked across the Web, a variety of educational applications of computers were proposed and to a lesser extent disseminated. In a review of instructional technology, Koschmann (1996) identified four broad approaches for incorporating computers in educational practices, namely Computer Aided Instruction (CAI) starting in the 1960s, Intelligent Tutoring Systems (ITS) in the 1970s, Constructive Learning Environments (Logo-as-Latin) in the 1980s, and Computer-Supported Collaborative Learning (CSCL) from 1995 on.

These four design paradigms were largely motivated by technological possibilities. Even in the 1960s, mainframe timesharing computers with many terminals were able to present texts to people sitting at the terminals, pose multiple-choice questions and respond based on the choice entered at their terminal. CAI applications were designed to take advantage of this automation mode. Later, tutoring systems took this a step further with a more sophisticated back-end using an AI approach to model both the domain structure (e.g., typical solution paths for a well-defined math problem) and a mental model of the student’s domain knowledge (i.e., how the student was approaching the problem solution). More exploratory learning environments took advantage of subsequent 2-D graphics support and personal computer facilities for end-user programming. Finally, CSCL responded to the networking of personal computers and the spread of the Web. Each approach raised new HCI issues—or suffered from a lack of HCI analysis. The four approaches have all had limited successes and are still active in the instructional technology marketplace.

Each of the four approaches has simultaneously offered tools for classroom education and threatened the institutions of schooling. They all allow people to learn outside of school. Some have been particularly popular for home schooling and for after-school programs, as well as for industrial training workshops.

In terms of the focus of this paper, it is important to distinguish CAI, tutoring and constructivist environments (on the one hand) as software for individual usage *versus* CSCL (on the other hand) as inherently for small-group usage. While the first CSCL system—CSILE (Scardamalia & Bereiter, 1996), aka Knowledge Forum—has been used in classrooms around the world for a decade, most other CSCL systems are still in the research prototype stage.

The New Perspective of the Learning Sciences

Leading, or at least paralleling, the changing paradigms for learning technologies was the evolution of theories in the learning sciences (Sawyer, 2006). Moving away from the traditional educational theories of Thorndike (1914), they recreated many of the ideas of Dewey (1938/1991), supporting them with the developmental and social psychology theories of Piaget (1990) and Vygotsky (1930/1978). In particular, they increasingly recognized the socio-cultural situatedness of learning in communities-of-practice (Lave & Wenger, 1991). In this, they followed much the same path as the situated-cognition critique within AI and computer science (Winograd & Flores, 1986).

Perhaps the most important influence on the learning sciences for the focus of this paper was the reception of Vygotsky's theory of social mediation, in particular his principle of internalization. This says that most higher functions of human thought are first learned socially, as part of interactions among people; they can later be internalized and transformed into individual mental skills (Vygotsky, 1930/1978, pp. 52-57). This principle is associated with his concept of the zone of proximal development, in which a learner can engage socially in collaborative work on a task that they would not yet have been able to accomplish on their own internally.

In our perspective, Vygotsky's theories—although not fully worked out in his brief lifetime—emphasize the importance of small-group interaction to the construction of meaning, representations, tools, symbolic artifacts and knowledge resources, both for the culture and for the individual. The implications of this theory have yet to be taken into account by the aims, procedures and institutions of contemporary schooling.

The Trouble with Computers in the Schools

The primary problem with how schools have adopted computers is their technology-driven view of the social role of computers. Under pressure to do something to improve schooling and to make it seem more up-to-date, politicians, administrators and parents have pushed to equip schools with computer hardware and Internet access. Of course, these are necessary, but not at all sufficient. The major problem is a lack of adequate educational software. In addition, there are needs for providing teacher training and on-site technical support. The hardware is often set up with little provision for meaningful computer-based curriculum and associated infrastructure. HCI was born to address the trouble with computers in industry. Now schools face an analogous—and overlapping—problem.

HCI was able to improve the lot of industrial software by increasing its reliability, usefulness and usability by insisting on a human-centered approach to design (Landauer, 1996). As we shall see, the problem is more complex for educational applications, involving the adoption in practice of the new learning sciences theories.

The EETI Study

A recent US Congressional study (EETI, 2007) looked at software for reading education and for math education. Here, we will focus on the math software because that is a main example in this paper. Three unnamed math applications were tested. According to the standards of the testing, the classroom use of these three applications had no significant effects on learning outcomes. From the characteristics given of the applications, it sounds like they were all examples of the CAI paradigm of drill-and-practice by isolated individual students.

There are many legitimate educational goals for which one might enlist instructional technology. As already pointed out, there are completely different approaches taken by educational software and many different exemplars in each category. That certain software based on a 50-year-old approach may not inspire millennial children under certain conditions does not mean that software cannot be developed to be effective for educational purposes. Even CAI has its benefits for certain people trying to achieve specific goals.

The first problem in designing and assessing educational software is that one really needs to invent new and innovative approaches, based on current theories of the learning sciences. These are hard to test because one needs to develop prototypes that are robust enough to use in real classrooms over long enough periods that teachers and students can become familiar with them. Furthermore, they may require new kinds of assessments, different from those appropriate for CAI applications.

The Dim Future of the University

It is popular to write essays and books on the negative effects of computerization on learning. An influential critical essay in *Science* (Noam, 1995) made a number of important points about problems involving how computers have been introduced into schooling. Primarily though, the author, Noam, conceived of educational software as something to be used by isolated individuals. He then saw that an education based on interaction with a computer would be missing the socializing aspects of, e.g., an undergraduate on-campus experience. However, he never considered that software can also be used to promote social contact, as can be seen not only in educational applications that incorporate discussion forums, chat, IM, wikis, websites, etc., but even more in the recent phenomena of social-networking software. Social networking, interestingly enough, is particularly popular among college undergrads. In response to Noam, one might inquire how social networking could be integrated into educational technology so that online learning would be a social experience, rather than an isolating, alienating one.

Computer-Supported Collaborative Learning

This is, of course, where CSCL steps in. The research field of CSCL—with its conferences, journal, book series, workshops, projects and labs—is devoted to developing ways to harness computer technology to support the rich social dimension of learning through collaboration (Strijbos, Kirschner, & Martens, 2004).

The computational power of computers has the potential to provide many kinds of tools to extend human capabilities and to transform routine or complex intellectual tasks into tasks that are more interesting or feasible. With its graphic capabilities, the computer can run simulations of scientific or mathematical models and allow groups of students to explore them. With global networking, computers can put students in touch with their peers around the world, to learn each other’s language and culture or to work and socialize together. The ability of computers to interact based on programmed instructions allows them to guide students through arbitrarily intricate and adaptable sequences (or scripts) of group and individual activities.

CSCL takes many approaches to mixing these potential benefits of computerization. The CSILE software was designed to allow a classroom full of students to collaboratively build scientific knowledge and theories asynchronously over periods of several weeks (Scardamalia & Bereiter, 1991). The WebGuide software I developed at the University of Colorado also provided an asynchronous medium—threaded discussion with personal and group perspectives—to support collaborative knowledge building (Stahl, 2006a, Ch. 6). Argumentation software typically helps dyads of students to reflect on the structure of their debates and organize the logic of their thinking and persuasion (Andriessen, Baker, & Suthers, 2003). The VMT software that we will present in this paper is designed for groups of 2 to 10 students to discuss mathematics in real time.

Whatever the techniques, media and domain, CSCL software is intended to foster collaborative learning and knowledge building by a group. Individuals may learn by participating, and perhaps by internalizing the experience, as Vygotsky described.

The Problem of User-Centered Groupware Design

Software for collaborative learning—like that for workplace learning and community learning—is associated with significant HCI issues, that exceed the difficulties of single-user desktop-interface and web-page design. They call for new theories, assessment tools and principles. They must centrally take into account the interactions among group participants as mediated by the software medium, and not just the interaction of an individual user to an interface. The number of possible combinations of views of the software by different participants at any given time and the variety of interactions possible explodes, making HCI analysis techniques from the 1980s inadequate. Many technical problems and many potential uses of the software are unpredictable and have to emerge from actual usage by groups of people under naturalistic conditions. This limits the utility of scenarios, mockups, walkthroughs, prototypes and lab studies as assessment tools—as essential as they may still be to specific phases of the design process (Preece, Rogers, & Sharp, 2007).

Social Networking and Web 2.0

Despite the difficulties facing the development of effective collaborative learning technology, the potential benefits loom larger than ever. The recent increase in Internet usage, particularly by high school and college students, bodes well for the adoption of new educational technologies. In particular, the popularity of a range of social networking sites and of so-called Web 2.0 interactive technologies has already instilled a familiarity with computer-supported collaboration, its handiness and its benefits.

The following sections of this paper will discuss studies that we have undertaken recently to take advantage of the social networking phenomenon to promote collaborative learning of domain knowledge in high-school math classes and university HCI courses.

Designing for Virtual Learning Communities

The Virtual Math Teams Project

The VMT project is a collaboration of the College of Information Science and Technology and the Math Forum digital library at Drexel University, funded by NSF from 2003-2009. Its primary goal is to catalyze and support a community of math discourse, particularly for middle-school and high-school students.

We began by building on a successful service at the Math Forum called Problem-of-the-Week. In the original service, an interesting challenge problem in pre-algebra, algebra or geometry was posted on the Web weekly and students worked on it at home, in school or during math club. Students could submit their solutions and their analyses to get feedback. The best solution statements were posted in the Web archives. Presumably, most of the math problem solving was done individually. We set out to make that a collaborative process.

We also took advantage of the huge popularity of text chat. We initially adopted AOL’s instant messaging tool, which was already quite familiar and accessible to students. Students who came to our site were placed into small groups in an AIM chat room and given a math problem to explore. If they wanted to exchange a drawing, they could email it to us and we would post it where the group could view it.

Use-Centered Research

By starting with software and procedures that were already proven in use and were familiar to the students, we finessed the design start-up issues that can bog down groupware development efforts. We were able to quickly observe students "in the wild" doing math collaboratively. By starting simply, we could allow our development process to be driven by observation of actual usage.

We had previously tried to do a face-to-face trial in a Philadelphia public school to get a feel for how collaborative math works in that kind of setting. Although informative, that effort showed how unusual collaboration in school math is and how complex it is to analyze. By contrast, our chat logs immediately revealed that students could quickly adapt to online collaborative math problem solving and that we could observe much of interest about how they accomplished that (Stahl, 2006c).

A Design-Based Research Process

We adopted the kind of design-based research process (Design-Based Research Collective, 2003) which has been broadly adopted in the learning sciences. This is an iterative inquiry process in which we modify the software environment, the kinds of math problems and the pedagogical script a couple of times a year. We invite students to participate in online groups in the new environments. Then we analyze the logs of their interactions to determine what was good in the service design and where improvement was needed. We thereby gradually build an understanding and theory of chat-mediated interaction and online collaborative math problem solving.

In terms of the technology, we tried a number of commercial and open source environments, combining chat with a shared whiteboard drawing space for geometric figures. Eventually, we contracted with a research lab in Germany (Fraunhofer-IPSI) to modify their ConcertChat software for our needs. We also began to develop a portal front-end to support social networking (Stahl, 2006d).

The kinds of math problems evolved considerably. From well-defined challenge problems, we moved toward mathematical mini-worlds for exploration and encouraged groups to define their own math questions to investigate. Over the years, we have gathered a corpus of 1,000 student-hours of interaction logs. We developed a replay tool that allows us to recreate the full interaction and review it in detail.

Perhaps the most important development was at the theoretical and methodological level. We gradually developed a theory of group cognition and a methodology of chat interaction analysis, as discussed toward the end of this paper. This resulted in about 50 publications reporting findings of the VMT project and analyzing its logs (see http://vmt.mathforum.org/vmtwiki/index.php/Studying_Virtual_Math_Teams#Writings_on_the_Virtual_Math_Teams_project for references and links to the publications).

Creating Joint Problem Spaces

It became increasingly clear from our analyses and from the related CSCL literature that for our students "collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p. 70).

Different technologies can provide different kinds of support for the construction and maintenance of shared conceptions. For instance, chat, whiteboard and wiki have different forms of persistence for inscriptions. Student groups are very sensitive to these differences and exploit them in subtle and inventive ways. Designers cannot predict many ways that these spaces will be used without observing actual groups of interacting students trying to work out their tasks situated within specific environments.

A major issue for groups working in environments with multiple workspaces (e.g., chat stream and shared whiteboard) is how to coordinate communications in the spaces and how to shift group attention from one space to the other. Special tools can help with this. When we adopted ConcertChat, it included a referencing tool that could point from the chat to the whiteboard. We observed the power of this tool for supporting the equivalent of pointing gestures and deictic references in the disembodied online context (Stahl, 2006b).We recently added wiki spaces and multiple tabs to the whiteboard, facilitating collaborative Web browsing, wiki editing, help access and viewing of the math task. Combining these spaces with the social-navigation portal and its various tools, the VMT environment has come a long way from its AOL IM starting point.

In order to orient students to the current, complex environment, we have had to develop training and help facilities as well as sometimes involving the students' teachers in providing basic training. We have also found that it is effective to engage the same groups of students across multiple sessions, making planning more complicated and fragile. Having sequences of multiple sessions brings enormous learning benefits. Not only do the students become more familiar with the affordances of the environment, but they are able to explore the mathematics more deeply and reflectively. We are able to script the sessions to gradually build understanding (Dillenbourg & Jermann, 2006). We can also take advantage of the intervals between sessions to provide feedback and suggestions without interfering with the delicate group interactions.

A Design for Collaborative Math Learning: Virtual Math Teams

As the software design and pedagogical scripting become more complex, it is important to maintain integration. The graphical referencing tool in ConcertChat along with history and social awareness functions help to integrate the main workspaces for students: the chat and the whiteboard (Mühlpfordt & Stahl, 2007). In order to support a global community of student users, we gradually sandwiched the synchronous chat-room-with-whiteboard between a portal and a wiki. The portal was designed to support social networking within the community so that students can find peers to collaborate with and then find a chat room to meet in. The wiki was designed to gather the results of the small-group chats and make them available in an organized way to the whole community. One way to think about this is that the portal or "VMT Lobby" support individuals to find their way around and to define their identity; the VMT Chat rooms support the collaborative activities of small groups; and the wiki shares the work of the entire community. The integration of the individual, group and community levels of activity require software integration of the various components.

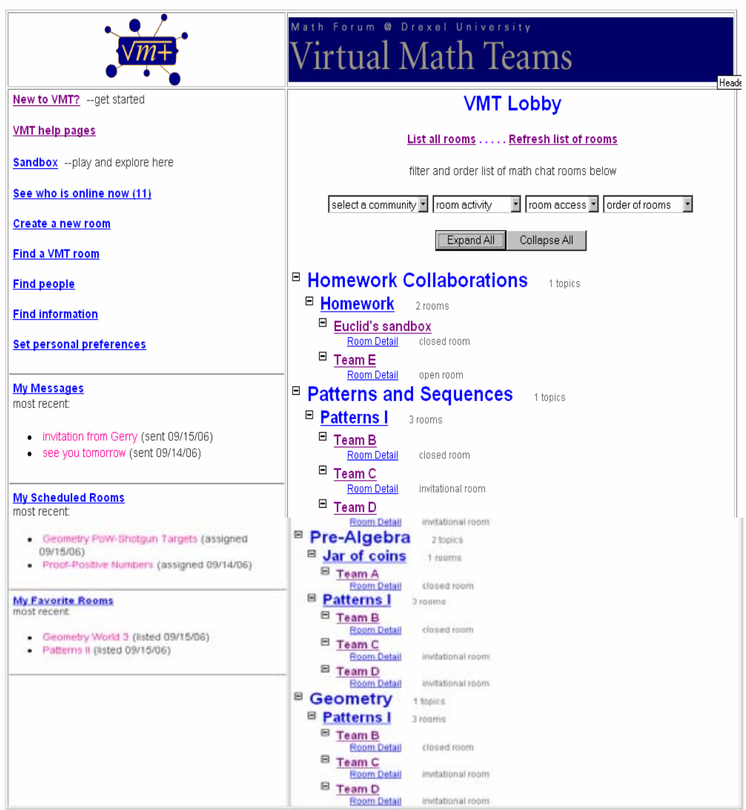


Figure 1. The VMT Lobby.

Figure 1 shows an image of the VMT social networking portal in its current state. On the left are tools for defining and viewing personal profiles—in general, students in a VMT group have no knowledge about each other except

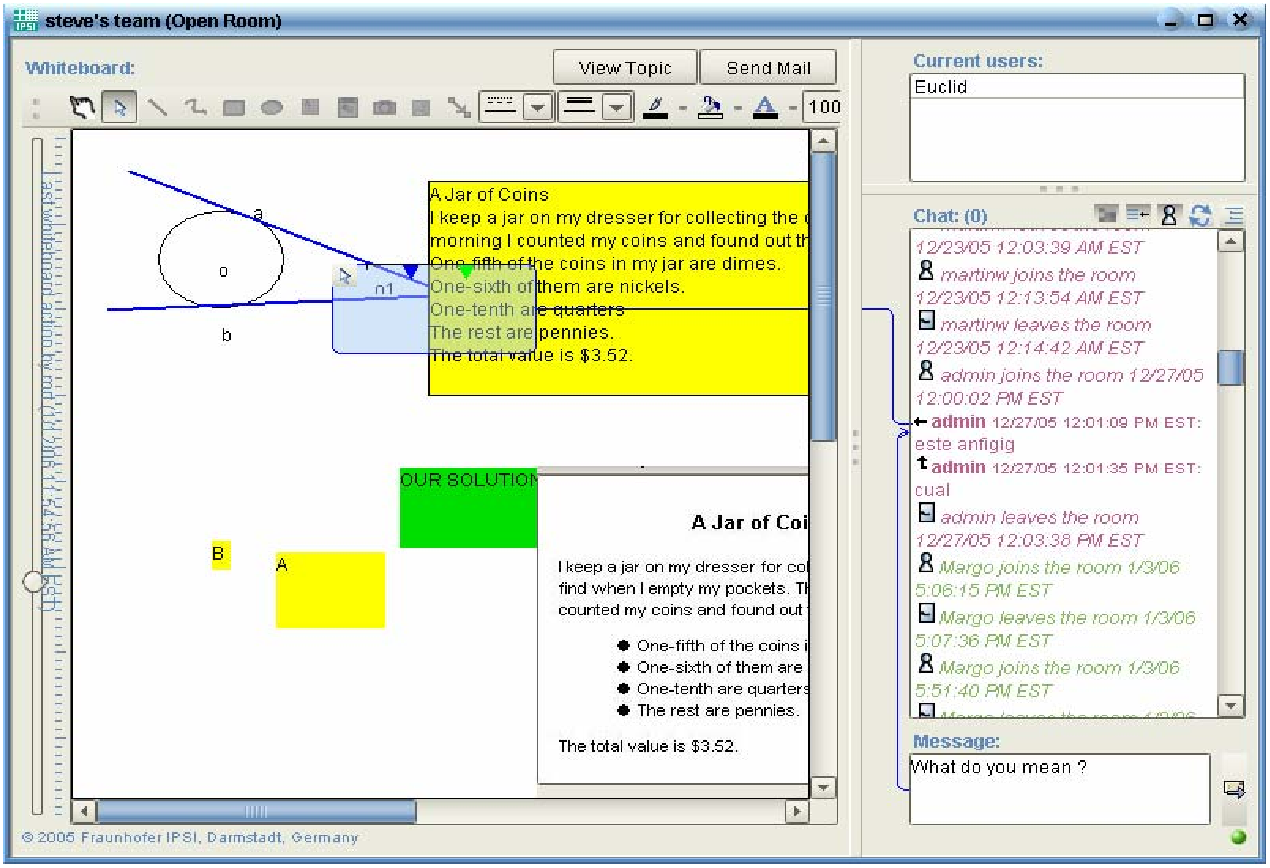


Figure 2. A VMT chat room.

for what is publicly posted in these profiles or revealed in the chat interaction. There is also support for messaging, defining buddies, listing favorite chat rooms, etc. On the right is an interface for searching and browsing available chat rooms. All available information is, by default, filtered based on one's "project" or sub-community. Most students are only interested in interacting with other students engaged in the same broad project, such as a VMT contest series.

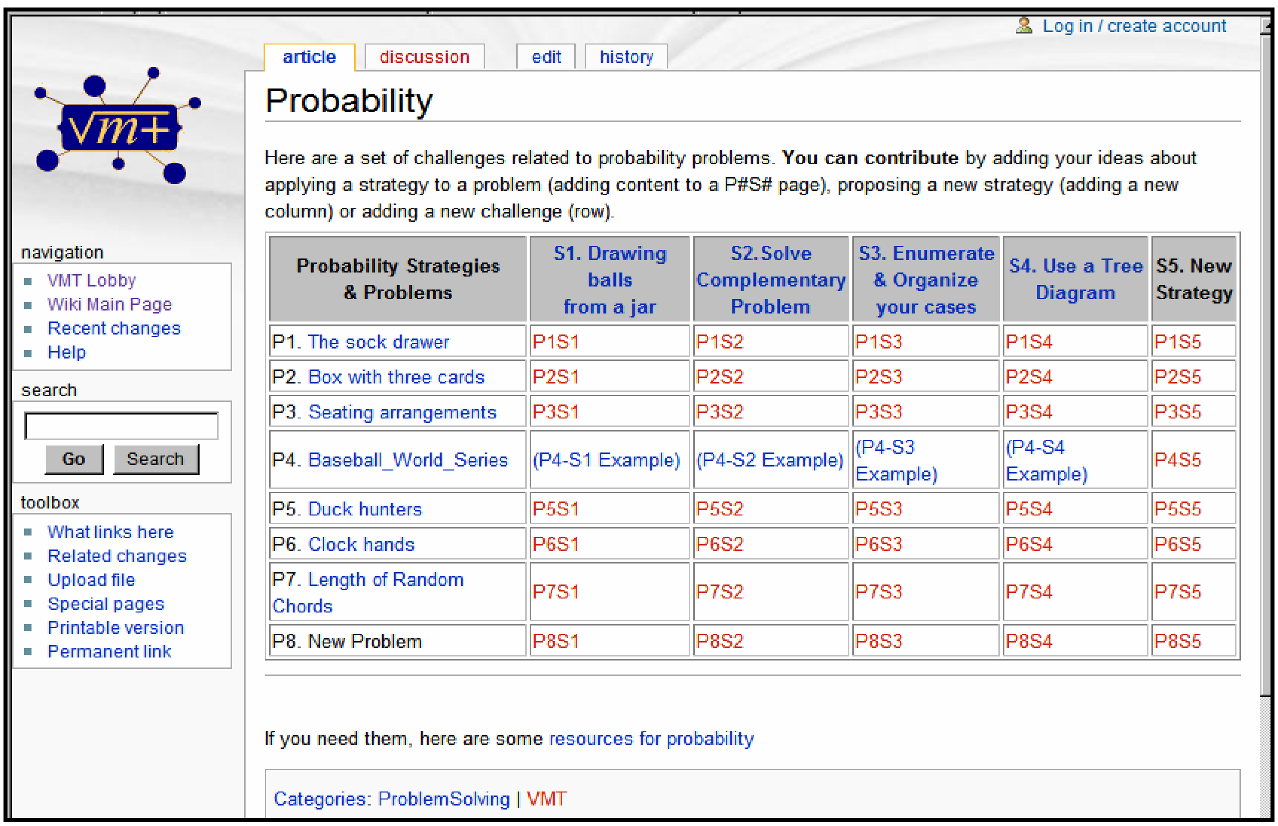
Figure 2 shows a typical chat room, consisting of the text chat interface on the right and the shared whiteboard on the left. Note that the user is currently pointing to a previous chat posting that she has scrolled back to, and that the referenced chat message was pointing to a translucent rectangle selecting part of the whiteboard. As seen here, the whiteboard supports a wide range of uses, such as displaying the problem text, affording the construction of simple diagrams and posting solution proposals in ways that are persistently visible and easily editable. The history of the whiteboard state can be scrolled through, much like that of the chat, but unlike the chat it usually retains inscriptions in the visible board as long as they are relevant.

Once we had the portal and the chat rooms working effectively to support small groups, we wanted to have the groups share their findings. Of course, students could visit chat rooms of other groups and read through their lengthy chat deliberations, but this rarely occurred. We wanted a way for groups to summarize their findings—at least at the end of a session and potentially at other points scripted for this in the topic description. We decided to set up a wiki that could be structured and edited by us as administrators, by the system as an automated feature and by the students who would post the actual content and read or respond to what other students had posted.

Of course, including a wiki meant that students would have to learn to navigate between the portal, the chat rooms and the wiki and would have to learn how to post textual and graphical contents in the portal profiles, the chat stream, the whiteboard and now the wiki pages. We had to supply some supports and integration to make this manageable. First, we extended the whiteboard to a tabbed interface with the original whiteboard for group work, a second whiteboard for the group to maintain a summary of their work, an easily accessible description of the topic for the room (the task description for the group), a special shared browser pointing to a wiki page associated with the chat room, a regular web browser (lacking the history and graphical referencing features) and a help manual.

To integrate the wiki with the chat environment, we automatically created a new wiki page every time a chat room was created; the two were associated with each other. We gave the new summary tab in the chat room the ability to automatically post its summary text to the associated wiki page. We added a link to the wiki in the portal as well as the tab displaying the associated wiki page. That way, users in the chat room could easily read and even edit the wiki page without leaving the room. Because it became harder to keep track of where group members were with the multiple tabs, we added social awareness signs to show what tab each person was currently in as well as what tab a graphical reference was pointing to. In order to keep the wiki organized, we used the category function of MediaWiki: when a chat room was created, the associated wiki page was categorized with the room name, the topic name and the math subject name. Using these categories allows one to easily find all the wiki pages summarizing work on a given topic, for instance. We also created some introductory wiki pages, like the one shown in Figure 3. It is for a VMT Spring Fest contest on probability problems. It points to wiki pages that summarize student work on a number of different math problems using a number of different problem-solving strategies.

We have just begun to use the expanded VMT system with the wiki integration. The VMT project



Probability

Here are a set of challenges related to probability problems. **You can contribute** by adding your ideas about applying a strategy to a problem (adding content to a P#S# page), proposing a new strategy (adding a new column) or adding a new challenge (row).

Probability Strategies & Problems	S1. Drawing balls from a jar	S2.Solve Complementary Problem	S3. Enumerate & Organize your cases	S4. Use a Tree Diagram	S5. New Strategy
P1. The sock drawer	P1S1	P1S2	P1S3	P1S4	P1S5
P2. Box with three cards	P2S1	P2S2	P2S3	P2S4	P2S5
P3. Seating arrangements	P3S1	P3S2	P3S3	P3S4	P3S5
P4. Baseball_World_Series	(P4-S1 Example)	(P4-S2 Example)	(P4-S3 Example)	(P4-S4 Example)	P4S5
P5. Duck hunters	P5S1	P5S2	P5S3	P5S4	P5S5
P6. Clock hands	P6S1	P6S2	P6S3	P6S4	P6S5
P7. Length of Random Chords	P7S1	P7S2	P7S3	P7S4	P7S5
P8. New Problem	P8S1	P8S2	P8S3	P8S4	P8S5

If you need them, here are some resources for probability

Categories: ProblemSolving | VMT

Figure 3. The main wiki page for the VMT Spring Fest on probability problems.

provides a rich case study of how important HCI analysis is for the design of new technology, but also for how limited traditional HCI methods are for understanding the computer-mediated human-human interactions. Our methodology of chat interaction analysis and our underlying theory of group cognition—discussed below—try to address these needs.

While the VMT environment has been tuned to the needs of high-school math students, it has proven effective for other collaborative activities as well. The specifically math-oriented functions—like our implementation of MathML for displaying equations and the whiteboard's stock of Euclidean shapes—play a relatively small role. The tools for integrating the multiple work spaces—like the graphical referencing from chat, the creation of wiki pages corresponding to each chat room and the automatic posting of summary text to the proper wiki page—are more important and are applicable to all knowledge domains.

Our collaborators at other locations (Newark, Pittsburgh, Wisconsin, Hawaii, Montreal, Singapore, Brazil, Israel, Germany) and we use the VMT environment for coordination of our design work on VMT, for collaboratively critiquing each other's research papers, for holding virtual committee meetings, for pre-teacher training and for student collaborations in other domains like physics or argumentation. Each of these different uses can work effectively in our current environment, but each also suggests new features tuned to the new application. We now turn from considering HCI issues in the design of the VMT environment for supporting interaction of math students to the use of the same system for teaching design to HCI students.

A Design for HCI Education: Designing Social Networking

In Spring Quarter 2007, while we were completing our latest major software upgrade to VMT, I decided to try basing my online HCI masters-level course on the VMT system. I had been planning to teach a CSCL seminar, but at the last minute I was reassigned to this online course, with students as far away as Hawaii. In my research, we were working on integrating wikis into VMT, so in my teaching I decided to move my course home and the student-group websites into a wiki—away from Blackboard and HTML websites.

This was my first online course in several years, and gave me a chance to try out what I had learned in the interim from the VMT project. I also used the opportunity to try out the new VMT chat/whiteboard/wiki environment in a context where I could define the course myself and guide the students first-hand. I found it surprisingly easy to set up the entire course in a wiki, with clear instructions for the students and a clean organization of resources—see Figure 4. Each week, the students held several online meetings with their workgroups in VMT chat rooms, where they discussed the readings and their design project assignments. They summarized their discussions in their shared whiteboards and then posted their summaries to the course wiki. I provided general feedback and guidance in the wiki as well. The wiki and the chat rooms with whiteboards are persistent and serve as permanent documentation of the course and all its interactions and details.

The students read the whole of a newly-revised and comprehensive HCI textbook (Preece *et al.*, 2007) as well as 18 research papers about CSCL and VMT. The textbook provided a thorough overview of the field and related background information. The papers served in place of lectures. Students maintained individual journals on the textbook chapters and reflected collaboratively on the papers. Each group posted its critiques of the papers in the wiki, where the other groups could read them and I could comment on them.

Figure 4. The main wiki page for the HCI course.

The heart of the course was a group project, spanning most of the quarter, with weekly milestones requiring postings to the wiki by each group. The groups met several times a week at their convenience in VMT chat rooms to work on their group project and to discuss the readings for the week. As they discussed, they summarized their ideas on the whiteboard for posting to the wiki. That way, the whole group could draft the postings and if anyone missed a meeting they could catch up quickly without reading through a long chat log.

The group project was to design an extension to the VMT software that they were using. The extension was supposed to support social networking, so that potential users of the VMT system could find others with similar skills, interests and availabilities to form groups.

The ten-week hands-on project was divided into weekly assignments, which paralleled the stages of the textbook's design model and matched the chapters and papers read the previous week:

1. An ice-breaker design project to help the students get used to working together in the VMT environment.
2. Literature search on social networking and Web 2.0.
3. Analysis and statement of problems in social networking.
4. Establish requirements with use cases and scenarios.
5. Conceptual design (this was done as an individual paper).

6. Interactive prototype and scenario.
7. Heuristic evaluation of another team's prototype.
8. Cognitive walkthrough of one's own team's prototype following a scenario.
9. Final, revised design for a new social network function in VMT.
10. In the final week, individual students submit their textbook journals and a reflection paper on their experience learning about HCI in the course.

Classroom learning is contextualized within a global horizon by situating the knowledge built by the groups within current HCI research issues. These are explicitly discussed as the student groups design and prototype solutions that apply the HCI concepts in the readings. The issues emerge mainly in the collaborative chat interactions: practice and group discussion inform each other.

The idea of collaborative peer learning through hands-on practice—which is fundamental to the course approach—is presented to the students through the syllabus document and some of the readings. The grading system stated in the syllabus shows that collaborative learning is a combination of efforts at the individual, small-group and classroom level: the grade is based on a combination of these. The assignments mix individual and small-group efforts, and the results are mostly shared and assessed at the class level.

By having the students work in the environment that they are designing for, they acquire first-person experience from a user perspective. Comprehensive histories of the interactions within the system are persistently available, so the students as designers can study their own usage of the system reflectively and analytically. It is thereby natural for the students to compare their subjective and objective analyses of the user experience. The collaborative structure of the course stimulates, encourages and supports discussion of issues of HCI and education.

The collaborative learning approach of the course is in many ways at odds with the culture at Drexel, which is traditionally an engineering school. Yet, as evidenced by the reflection papers, the students learned to appreciate the many aspects of collaborative learning in the course. Perhaps because they were mature students who knew that the work-world is increasingly organized into collaborative teams, they could understand the advantages better than undergraduates. Maybe because they were accustomed to taking online courses in which there is no social contact, these students enjoyed the interaction with their peers.

Theory and Methodology of Group Cognition

The challenge is that current software support for online collaborative learning is primitive at best. There is a tremendous need for HCI work to help develop effective collaborative learning software. The help is needed at a deep level, not just superficial changes to the look-and-feel of the interface. The nature of computer-mediated human-human interaction must be understood and new media and functionality must be designed to support it.

To investigate the design of software to support online collaborative learning in the domain of school math, the VMT project adopted a design-based research approach. This involves gradually developing the software in response to frequent cycles of user trials in naturalistic settings. This approach calls for analysis of the effectiveness of the software in achieving its goals at each cycle of testing (Design-Based Research Collective, 2003). However, the design-based approach as such does not specify a method of analysis. Somehow, the support for human-to-human interaction and collaborative knowledge building must be analyzed.

The VMT project and my previous research have contributed to a theory of group cognition (Stahl, 2006a). This theory conceptualizes collaborative knowledge building as fundamentally consisting of group processes, largely linguistic in nature. The theory points to the field of conversation analysis as an example of insightful findings about linguistic group processes, such as the structure of turn taking in social conversation (Sacks, Schegloff, & Jefferson, 1974).

For researching the nature of group cognition, the VMT project has developed a methodology of *chat interaction analysis*. This supplies the missing analysis method for design-based research in the area of computer support for collaborative learning. Like conversation analysis, we wanted to take an ethnomethodological approach (Garfinkel, 1967) to understanding the *methods* that people use to collaborate online, rather than imposing theoretical categories on our data.

We could not simply adopt conversation analysis for two major reasons:

1. Conversation analysis is concerned with a very different context, one in which people are physically present to each other and are speaking and gesturing. In the VMT media, disembodied interaction takes place through text and other inscriptions.
2. Conversation analysis is methodologically driven by how the participants themselves understand what is going on. Investigating effects of design decisions imposes an external analytic perspective, which is anathema to pure conversation analysis.

The development of our theory of group cognition and our methodology of chat interaction analysis in response to these issues are by no means complete. They are only meant to point out some of the major methodological and theoretical issues facing fields like CSCL and HCI.

If HCI is to respond to the needs of education today—including education of HCI students—then it needs to address the issues that this paper has tried to raise. As I tried to detail in the three parts of my book (Stahl, 2006a), the attempt to (i) design effective modalities for computer interaction with people engaged in online, computer mediated collaborative learning and knowledge building opens up (ii) methodological issues of analysis of text-based disembodied interaction and (iii) theoretical issues of group cognition.

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