Technology and pedagogy for collaborative problem solving as a context for learning

Timothy Koschmann, Denis Newman, Earl Woodruff, Roy D. Pea, Peter Rowley

TECHNOLOGY AND PEDAGOGY FOR COLLABORATIVE PROBLEM SOLVING AS A CONTEXT FOR LEARNING: REPORT ON A CSCW'92 WORKSHOP

TIMOTHY KOSCHMANN, DENIS NEWMAN, EARL WOODRUFF, ROY PEA AND PETER ROWLEY

This workshop, sponsored jointly by CSCW '92 and the Centre for Applied Cognitive Science at the Ontario Institute for Studies in Education (OISE), was organized to bring together researchers with interests in the emerging area of Computer Support for Collaborative Learning (CSCL). It was held at OISE on the weekend preceding CSCW '92 and was attended by 27 participants from academia and industry.

There is a movement for reform in schools currently, which centers around changing the nature of the educational activity from teacher-led lessons on subject matter content to project-based work in which students are active problem-solvers and theorists, while the teacher plays more of a coaching role. Very often, the complexity of the projects invites collaborative work as a way to bring multiple perspectives to the problem and for students to learn from each other. We are seeing collaborative problem-solving being used all the way from elementary school classrooms to professional education.

While it has been observed that placing computers in classrooms often results in changes in the amount and kind of group work, we are just beginning to develop and study technology specifically designed to support collaborative project-based school work. Problem-solving was the focus of the workshop because of its relation to school reform and restructuring efforts and because it is a domain of pedagogy that can benefit most immediately from the developments in CSCW technology. Problem-solving includes activities such as collecting and analyzing data, working with simulations of physical or biological systems, finding the best mathematical analysis of a real-life scenario, and the case-based learning used in many schools of law and medicine. Collaborative problem-solving in schools is making use of computer tools for analysis, simulation, display, and communication (Koschmann, 1992). The workshop explored ways of molding both the technology and the pedagogy to best support student collaboration.

ORGANIZATION OF THE WORKSHOP

The one-day workshop had three major components: an opening session involving all attendees, followed by a period in which participants were assigned to four "breakout" groups, and a closing session in which the subgroups reported on their discussions back to the group.

The opening session consisted of a series of presentations describing three prominent CSCL applications. These presentations provided a context for later discussions. Louis Gomez and Roy Pea described the Learning through Collaborative Visualization (CoVis) Project being conducted at Northwestern University in conjunction with numerous collaborating organizations (Pea, 1993; Pea and Gomez, 1992). Denis Newman described the Copernicus Program (Newman, 1992; Newman, Bernstein, & Reese, 1992) being developed for use in K-12 Schools, including the New American Schools Development Corporation (NASDC) Co-NECT School Partnership (Olds & Pearlman, 1992). Finally, the CSILE project at OISE was described by Earl Woodruff and Peter Rowley (Scardamalia, et al., 1992; 1989).

Following these presentations, the group of participants was divided into four subgroups reflecting their interests and past work. This division was based on the observed dichotomy between applications designed for use within the classroom and those designed for communication across classrooms via

Locus of Use	Focus of Research: Pedagogy	Focus of Research: Technology
Within Schools	Roy Pea (Moderator) Alberto Canas (West Florida), Ken Ford (West Florida), Trent Batson (Gallaudet), Ester Tiessen (OISE), Jolene Galegher (CMU), Fred Siegeltuch(Argonne Labs), Wayne Grant (Apple), Dadong Wan (Hawaii)	Peter Rowley (Moderator) Chris Neuwirth (CMU), Elliot Solloway (Michigan), Doug Ward (OISE), Jason Lewis (IRL), Timothy Koschmann (SIU), George Tracz (Toronto)
Across Schools	Earl Woodruff (Moderator) Jim Hewitt (OISE), Terry Mayes (Heriot-Watt), Naomi Miyake (Chukyo), Dana Paramskas (Guelph), Mitchel Resnick (MIT), Mark Schlager (SRI)	Denis Newman (Moderator) Louis Gomez (Bellcore), Andrew Cohen (OISE), John Thomis (NYNEX), Ted Kahn (IRL), Robert McLean (OISE)

Table 1: Composition of the Breakout Groups

wide-area networks. Crosscutting these two contexts for learning are distinct concerns for, first, design and implementation of technologies and, second, research into the design and evaluation of new pedagogical approaches that can best take advantage of these technologies.

Consequently, participants were divided on two dimensions—the locus of use for which their applications are designed (within or across classrooms) and the nature of their professional interests (either technical or pedagogical)—producing four independent breakout groups. The composition of the breakout groups is shown in Table 1. Each of the breakout groups was asked to develop a set of issues affecting advancement of the field. The results of these discussions are summarized below.

Across-Schools Technology Issues[1] (Denis Newman, moderator)

Internet technology, just now beginning to enter the schools, will create a demand for integrated applications that combine work within the classroom with electronic resources brought in from outside the classroom. Discussion in this group focused on issues of application "packaging," the problem of user information overload, and some of the social issues engendered by network-delivered education.

One of the challenges facing developers of across-classroom applications is how to package the application for widespread adoption in schools. It is often difficult to communicate real "cost benefit over time" to stakeholders. Further, there is a tendency on the part of school decision-makers to choose fully-integrated solutions. Unlike more traditional methods of instruction, instruction based on collaborative problem-solving usually does not rely upon a fixed set of instructional materials. CSCL applications, therefore, need to be designed in an open-ended fashion to maximize flexibility for use and future growth.

Increased access to on-line networks and multimedia resources may serve to induce information overload. Participants proposed three approaches to ameliorating this problem–using software "agents" to filter incoming information or to seek resources on the network, the development of better browsing/search/retrieval tools, and the use of advanced human-computer interaction (HCI) techniques for presenting information to users.

Even though the task of this breakout group was to identify technological issues, a number of social considerations were also aired. One issue concerns the ownership of work within the network-enhanced, collaborative classroom. This concern evidences itself in questions of privacy, plagiarism, copyrights, and student assessment. Another problem involves issues of social inequity. As these technologies become more powerful and their use more widespread, we must work to ensure that they do not serve to exacerbate the existing inequalities of access within the educational system (Paller, 1992). A third social issue is less a problem than an opportunity–namely, the possibility of using network-delivered education as a point of leverage for supporting community services outside the school system. Examples might include using electronic communication to effect greater community awareness and to provide continuing education for senior citizens and other homebound members of the community.

Across-Schools Pedagogy Issues (Earl Woodruff, moderator)

Discussion within this group eventually led to the question, "Is wide-area collaboration necessary?" A consensus emerged

[1] Notes for this breakout group were provided by Ted Kahn.

endorsing the necessity of large-area networks for particular contexts, instructional goals, and learner characteristics.

The context must be one that moves from the computer as a knowledge presentation device to one that supports a pedagogical focus on communications in support of collaborative learning ventures. Effective use of such contexts will be dependent upon having a sufficiently large pool of potential collaborators. Consequently, the need for a wide area network is apparent in both asynchronous applications such as CSILE (where inquiry driven applications require an aggregated pool of process and domain specific knowledge) and in real-time synchronous applications. The success of users browsing through real-time multiuser environments (so-called "cyberspace") looking for causal collaborations based on expertise and interests will depend upon the availability and number of potential on-line participants.

Discussion also led the group to consider the potential for wide-area communications to foster some important learner characteristics and instructional goals. In particular, the group noted the reflective nature of collaborative databases and the reification of the learning process for participants. How to preserve the reflective qualities of the databases, as well as the enhancement of their scholarly nature, stand out as important research questions. Further, a consensus was reached calling for research on such questions as: how do we include the passive learner in the process; should problem selection be assigned or self-initiated; what are the facilitators or impediments to maintaining an intellectual atmosphere; what information should be externalized/shared; and how do we ensure a usable and valued database within a wide-area context?

Within-School Pedagogy Issues (Roy Pea, moderator)

The greatest number and variety of CSCL applications are designed as intra-classroom applications. This group examined some of the pedagogical issues pertaining to within-school applications. Topics discussed can be categorized into three areas: issues having to do with the establishment of a culture for learning in the classroom, issues of application design, and issues for future research.

The success of collaborative forms of instruction hinges on the successful establishment of a culture for learning in the classroom. How does one establish and sustain a reform-minded setting for instruction? What arguments can be generated to win continuing support for this type of instructional initiative from the school administration? How does one go about retraining today's educators to assume roles as effective inquiry managers? What changes need to be made to the school infrastructure to support the interdisciplinary nature of project-based instruction? With respect to the design of new applications, are there ways in which technology can better support the process of collaborative instruction? For example, can the computer offer representational formalisms that can facilitate (or even collaborate in) the learner's construction of knowledge? Can technology assist in the coordination (e.g., turn-taking, access control, media interaction) of the group process? There are many open questions for future research. How can we best support teachers as expert inquiry managers? What features differentiate a good group coach from a mediocre or poor coach? While collaborative methods have been touted as a remedy for the effects of "tracking," what techniques can be used to ensure that differences in ability and prior learning do not diminish the usefulness of the instructional experience for more capable members of the group?

Within-School Technology Issues (Peter Rowley, moderator)

This group organized their discussion around three areas of concern: design, evaluation and dissemination. Applications must be designed to provide a high level of reliability. Participants agreed that this is often difficult to accomplish for a number of reasons. First, although stand-alone computers are reasonably reliable, it is hard to make networked systems perform reliably and at sufficiently high performance levels. This is important because delivery-based systems, such as those based on CD-ROM and videodisc and with which networked collaborative systems compete, can be made quite reliable and have sufficiently high performance. Second, in most school settings this performance must be achievable with minimal support resources. While many members of the group are building freestanding applications, most would prefer to be able to customize or build wrappers around existing commercial and noncommercial products. Yet the group agreed that there are a host of non-technological issues, such as how software is sold, that may be barriers to achieving the desired level of flexibility in customization.

The social context of eventual use must be considered in the design of effective instructional systems. The group, therefore, discussed design processes, goals of design, and underlying models of instruction. Several projects spent considerable effort on explicitly creating motivating social structures to encourage effective collaboration. Design must include careful pre-implementation analysis of task demands (e.g., How does a community really work? What kinds of activities do we want to support?). For example, one project looked at what writers find difficult and identified the important skill of asking hard questions. This led to the creation of a technique of playing 'devil's advocate,' where a social situation was created in which a student could feel comfortable about working hard at honestly critiquing a peer's work (Neuwirth, Palmquist & Gillespie, 1989). The group recognized that computer systems are by no means the only artifacts that must be designed. One project, for example, developed "survival guides" to provide novice users with guidance in the operation of the system while at the same time enculturating them into the community of use. With respect to issues of evaluation, participants conceded that the evaluation of technologies of this type can be exceedingly difficult. Much of the difficulty arises from the fact that most conventional measures, which focus on content, do not appropriately address the kinds of knowledge skills that many projects seek to develop. Nonetheless, some participants still thought it was important to use conventional measures, in order to provide a point of comparison with past work. Several novel evaluation models were presented, including the use of

video to support observational studies within the classroom activities, and the use of focus groups and attitudinal questionnaires. The deployment of systems and subsequent evaluation in multiple contexts was discussed as a way of coping with the fact that different communities can adopt the same collaborative system in very different ways.

Finally, considerable time was spent on problems of dissemination, that is the process by which a successful application is made available to a broader audience. On a practical level, participants raised concerns about what exactly to disseminate, educational support/training, and the structure of the social setting in which the application is actually used. They also observed that the dissemination phase of a project is often the most difficult to fund.

CONCLUSIONS

One common theme that emerged from these discussions is that CSCL applications, both those designed for use within the classroom and those designed to be used across classrooms, tend to emphasize access to learning materials as opposed to delivery of instruction. This reflects a shift in orientation from more traditional models of instruction in which knowledge is transmitted through lecture, text, and worksheet to a more student-centered approach designed to support individual construction of understanding. Such a shift calls for dramatic changes in the relationships both of students to their teachers and of students to their peers. The introduction of collaborative problem solving follows naturally from this shift in orientation.

Given this common orientation, it is not surprising that similar research issues arise in both within- and across-school CSCL applications. For example, there is a great need for research into the development of effective techniques for collaborative instruction. There is also a critical need for longitudinal studies of the effects of collaborative methods. Finally, efforts need to be made to integrate within- and across-school applications to better serve the needs of the classroom.

The common orientation toward access to learning materials, as opposed to delivery of instruction, also leads to common themes on the technical side. Much of the network infrastructure available either within schools or among schools consists of closed, single-purpose systems. While these systems may simplify management and support school administrative functions, they do not provide support for project-based or exploratory school work. Neither do they support the connection between local- and wide-area networks for instructional purposes. There is a great need for the development of technologies that will support broad, easy-to-use access to peers and resources both within and outside the school.

This workshop played two important roles. First, it served to bring together representatives from diverse application areas within CSCL in a way which enabled them to see some of their common interests and goals. Second, it began the process of constructing a bridge between workers in CSCL and the broader CSCW world. Learning is, after all, another form of work; it seems natural that the ties between these two communities will grow closer over time.

REFERENCES

Koschmann, T.D. (Ed.) (1992). Computer support for collaborative learning: Design, theory, and research issues. Special issue of ACM *SIGCUE Outlook*, *21*(3).

Neuwirth, C., Palmquist, M., & Gillespie, T. (1989). Role playing in peer review: The Devil's Advocate exercise. In D. Biel (Ed.), *Teacher's guide to using computer networks for written interaction.* Washington, D.C.: Realtime Learning Systems.

Newman, D. (1992). Technology as support for school structure and school restructuring. *Phi Delta Kappan*, *74*, 308-315.

Newman, D., Bernstein, S., & Reese, P. (1992). *Local infrastructures for school networking: Current models and prospects* (BBN Rpt. No. 7726). Cambridge, MA: BBN Systems and Technologies.

Olds, H.F. & Pearlman, R. (1992). Designing a new American school. *Phi Delta Kappan*, *74*, 296-298.

Paller, C. (1992, September). Separate realities: The creation of the technological underclass in America's public schools. *MacWorld*, pp. 218-230.

Pea, R. (1993). The Collaborative Visualization Project. *Communications of the ACM*, 36(5), 60-63.

Pea, R. & Gomez, L. (1992). Distributed multimedia learning environments: Why and how? *Interactive Learning Environments*, *2*, 73-110.

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

Scardamalia, M., Bereiter, C., McLean, R.S., Swallow, J. and Woodruff, E. (1989). Computer-Supported Intentional Learning Environments, *Journal of Educational Computing Research*, *5*(1), 51-68.