

CRLT Technical Report No. 5-98

**Critical Thinking in a Distributed Environment:  
A pedagogical base for the design of conferencing  
systems**

Thomas M. Duffy, Bill Dueber, & Chandra L. Hawley  
November 20, 1998



INDIANA UNIVERSITY

W.W. Wright Education Building, ED 2026  
Bloomington, IN 47405-1006

## **Critical Thinking in a Distributed Environment:**

### **A pedagogical base for the design of conferencing systems**

There is a strong movement in education today away from a predominantly didactic model of instruction and toward a learner-centered model where the learning activities involve students in inquiry and problem solving, typically in a collaborative framework. The strength and breadth of this shift in the pedagogical landscape has been quite dramatic if we are to judge by the policy recommendations arising from national education organizations (AAAS, 1993; Brooks & Brooks, 1993; NCTM, 1991) or by an examination of the shifting focus of educational research. It is only recently, however, that similar calls for reform in post-secondary education have begun to grow as legislatures and national associations begin to question the quality of classroom experiences (Braxton, Eimers, & Bayer, 1996; Cooper, Prescott, Cook, Smith, & Mueck, 1990; The Wingspread Group, 1993).

As with primary and secondary schools, there is pressure for higher education to become more learner-centered. Despite this trend, university faculty have been slow to adopt these "new" learner-centered approaches to instruction. Braxton et al. (1996), in an assessment of faculty norms, found that there was little expectation among faculty to read or learn about teaching methods. In fact, their work revealed minimal indicators of a norm supportive of an egalitarian classroom in which it was acceptable for students to express views different from the instructor or direct comments to other members of the class. The lecture mode, involving direct "transmission of knowledge" with minimal student contribution, dominates not only the practice in faculty teaching but also the norms for good practice. There are exceptions, of course. Many small, liberal arts schools, for example, have a tradition of promoting critical thinking both in and out of the classroom (Fischer & Grant, 1983). However, the more common practice and expectation is that of a lecture-based environment.

In fact, a recent study by Nunn (1996) provides what we consider rather depressing data indicating the predominance of non-interactive, lecture based instruction. Nunn examined 20 faculty teaching upper division courses in a public university. The faculty were selected based on high student ratings and general recognition for the quality of their teaching. The courses were all in the humanities or social sciences and had an enrollment between 15 and 44 students. Furthermore, 73% of these students reported that the course was in their major. In effect, the reputation of the faculty, the level of the courses, the subject matter, and the class size were all optimal for creating a highly participatory, learner-centered environment. Yet, Nunn found that, averaged across all classes, student discussion took up only about 2% of class time. The discussion that did occur tended to be almost entirely teacher-directed rather than learner-centered. That is, contributions by the students tended to be in response to the teacher questions, consistent with the normative findings of Braxton et al. (1996) described above.

These normative and performance data do not necessarily reflect faculty opinions of what ideal or desirable learning environments should be, but rather they simply reflect the reality of classroom instruction. We assume that most faculty are interested in engaging students in meaningful dialogue in the content domain. There are too many examples of faculty spending extended periods in discussion with students outside of class time (e.g., during office

---

- This paper was originally published as: Duffy, T. M., Dueber, B., & Hawley, C. L. (1998). Critical thinking in a distributed environment: A pedagogical base for the design of conferencing systems. In Bonk, C. J., & King K. S. (Eds.). *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse*. Mahwah, NJ: Lawrence Erlbaum Associates.

hours) to believe otherwise. However, how does one carry on a meaningful discourse in a class of 40? It is only in an academic environment that we even consider that a meaningful discussion can occur with a group larger than ten or perhaps fifteen.

A second "reality" of the impact of the undergraduate classroom on the opportunity for meaningful discussion is the time available for meeting: the typical class meets only 2.5 hours per week. Given the joint constraints of the class time available and the size of the class, a faculty member must weigh the alternatives of spending that brief time in discussion that is likely to be superficial because of the number of students involved or in presenting a well designed (from the faculty point of view) lecture that he or she believes will help students understand the complex issues in the field.

In sum, we are confident that a highly interactive, learner-centered environment is a worthy goal in undergraduate education (or in any education or training environment) in terms of the quality of the learning experience (Astin, 1993; Johnson & Johnson, 1993). Interaction is valued as a vehicle for developing, through mentoring, the critical thinking skills of students. Furthermore, we assume that most faculty agree with this premise but are unable to see it as viable with the typical class size and limited meeting time of classes. Of course, faculty can assign collaborative inquiry tasks to be completed outside of class time (or even during class time). However, it is difficult in the classroom, and impossible outside of the classroom, to monitor collaborative discussion and critical thinking. Therefore the faculty can neither coach nor assess the inquiry. It is only the final product of inquiry that can be reviewed.

It is from this perspective that we focus on the design and use of network-based "conferencing" tools in this chapter. We view the large number of conferencing tools that have become available, particularly via the World Wide Web, as offering the opportunity for discussion to occur outside the classroom as well as providing an opportunity for the instructor to coach, participate in, and evaluate such discussion. Electronic conferencing systems allow the instructor to:

- observe students' contributions to the discussion,
- include transcripts of the discussions in a portfolio for feedback or grading,
- participate in the discussion to model critical thinking skills,
- interject questions and comments to coach critical thinking,
  - provide expertise in a topic area when such input is required.

In essence, the instructor can mentor and evaluate the critical thinking skills exhibited in out-of-class discussions. It is this potential of electronic conferencing systems that we find so exciting. There is an opportunity, not just in small liberal arts colleges, but throughout the post-secondary educational system, to create learner-centered classrooms that require and "teach" critical thinking.

Clearly the development of these conferencing tools, along with the ability to supply information resources using the World Wide Web, provides a new perspective on what can be accomplished in college courses and begins to blur the distinction between residential and distance learning environments. While the World Wide Web can provide new opportunities for rich, distance learning environments (Dolence & Norris, 1995; Harasim, 1990 ; Hiltz 1997), the same features can also provide new opportunities for increasing the quality of on-campus learning environments. We raise the issue of distance versus on-campus courses here only to note that the opportunities to

mentor and evaluate critical thinking in a domain or particular course through the use of conferencing systems applies equally to on-campus and distributed environments<sup>1</sup>.

Our concern in this chapter is the design of electronic conferencing systems that support both critical thinking and the mentoring of critical thinking. We have found that computer-based conferencing systems are typically distinguished only by whether they are synchronous or asynchronous — whether the discussion is in real time or not. There is a common assumption that discussion is an undifferentiated activity — all discussion is the same and we simply need a tool that allows "it." There is little consideration given to different kinds of discussion, the goals people have for discussion, or the impact of the design of a conferencing system on achieving the goal of the discussion.

We take the position that critical thinking is a particular type of goal-oriented activity that focuses on issue analysis and problem solving. Since particular skill requirements are associated with effective critical thinking, conferencing systems must support the use of those skills. Furthermore, because students must develop critical thinking skills, conferencing systems should support the mentoring of critical thinking. In the next section we examine the characteristics of critical thinking. From this discussion we will develop a richer understanding of what is required to support critical thinking in the collaborative inquiry process. We will propose an approach to the design of an asynchronous tool that highlights some features we feel are critical to supporting and promoting collaborative inquiry.

### **Critical Thinking and Reasoning**

A myriad of terms have been used to describe the focus of our interest: critical thinking, informal reasoning, informal argumentation, critical reasoning, inquiry, abduction, induction, etc. (Ennis, 1962, 1989; Facione, Sanchez, Facione, and Gainen, 1995; Paul, 1993; Kuhn, 1992; Barrows, 1993). We are not particularly interested in fine distinctions between these terms since we feel they all apply to the learning environment of our focus. In essence, we see inquiry as a key component of most learner centered environments (Savery & Duffy, 1996; Rochelle, 1992). By inquiry, we mean that the learner encounters a puzzlement or a perturbation of their expectations — something they cannot explain and that puzzles them<sup>2</sup>. This inquiry process has been described as both inductive and abductive reasoning (Shank, 1987; Voss, 1991). In either case, the learner must generate hypotheses, gather and evaluate evidence, consider alternatives, and come to a reasoned position on the issue. In essence, the learners must build an argument for their position. Of course, as Paul (1993) has noted so forcefully, it is not just the carrying out of these inquiry activities but it is the quality with which they are carried out that determines the quality of the critical thinking.

Critical thinking is seen as an essential skill for success in our society and has been heralded as a need not only in the Goals 2000 (REF) but in most curriculum analyses and in statements from the corporate sector. However, Kuhn (1992), has found critical thinking skills at a considerable deficit among a population of average

---

<sup>1</sup> We distinguish between distance education where students are at a distance from campus and distributed education. The fact that the learning activities and technology support can be used with students on campus as well as students at a distance is generally referred to as "distributed education" (Dolence and Norris, 1995; Oblinger and Maruyama, 1995).

adults reasoning about common societal problems. Further, the National Assessment of Educational Progress (1981), in reflecting on the performance of students in discussing readings they had just completed, notes:

Students seem satisfied with their initial interpretations of what they have read and seem genuinely puzzled at requests to explain or defend their point of view. As a result, responses to assessment items requiring explanations of criteria, analysis of texts or defense of a judgmental point of view were disappointing. Few students could provide more than superficial responses to such tasks, and even the "better" responses showed little evidence of well developed problem-solving or critical thinking skills. (pp. 28-29)

Our goal is to support students in collaborative inquiry which involves making sense of some problem or issue that puzzles them and building a rationale argument in coming to their position. While there are many features of such a system that must be considered, the overall design must be informed by a clear understanding of the collaborative inquiry process we seek to support. We have identified four dimensions of critical thinking and inquiry that have informed the design of the conferencing system we are beginning to build: 1) the common beliefs and goals that define the scientific community; 2) the structuring of inquiry; 3) the elements of argumentation; 4) the quality of the reasoning; and 5) collaboration in inquiry.

### **Beliefs and Goals**

While inquiry always entails seeking understanding or resolution of some issue, the beliefs and goals underlying the process, and hence, how it is conducted, can vary significantly as a function of discipline. Bereiter (1992) contrasts the assumptions underlying inquiry in the political, philosophical, scientific, and judicial communities. For our part, we see scientific inquiry as most pervasive across the disciplines and the most central educational goal. Bereiter (1992) distinguishes the scientific approach to inquiry by the commitment to:

- work toward a common understanding satisfactory to all,
- frame questions and propositions in ways that enable evidence to be brought to bear,
- expand the body of collectively valid propositions, and
  - allow any belief to be subjected to criticism.

These goals and beliefs can be contrasted to the political process where compromise is the goal as well as the legal process where winning is the goal. The inquiry process calls for individuals to value and use alternative perspectives to test their ideas and expand their understanding. Here, coming to agreement arises not out of compromise or a vote but through gathering additional evidence to evaluate ideas as well as seeking overall parsimony and robustness.

### **Structure of Inquiry**

What is the structure of inquiry or problem solving? What is it that individuals might not know or might forget about problem solving? There are many ways of characterizing the structure — each problem-solving model has its own representation of the process. (Bransford, 19 ; Hayes, 1995; who else). However, at a basic level we can define five components:

---

<sup>2</sup> Perturbation of the learner is essential. Their puzzlement is the basis for their assuming ownership of the learning activity, i.e., for the environment to become a more learner centered environment.

*Define the problem.*

First the problem solvers must identify the problem. Even though it is stated, there is a need to consider the constraints around the problem, new meanings that might arise from rephrasing the problem, and the ways in which it might be focused or expanded to provide a better understanding of the issues.

*Develop and evaluate solution alternatives.*

In seeking to develop a solution or position on the problem, they must generate possible solutions and critical issues, evidence, and counterproposals to be used in evaluating and fine tuning those possible solutions.

*Come to some resolution.*

There must be an active evaluation to the alternatives, moving toward resolving the problem using the best understanding of the moment.

*Developing a plan of action.*

The solution must be acted upon in some way. This may involve writing a paper that is an argument for the position or it might involve an implementation of a plan.

*Reflect on the process.*

Finally, it is essential that there be a reflective process to evaluate the effectiveness of the problem solving and to synthesize, evaluate and index what was learned. This is a critical learning activity that is too often ignored. Reflection is essential not just for school environments, but for any problem solving activity if the goal is to learn from and capitalize on the experience. In business, it is generally referred to as "debriefing" on the project or engagement.

Of course these five components do not play out in a linear fashion. Evaluating potential solutions will almost certainly lead to new thoughts on problem constraints or parameters as well developing a plan. And of course, developing a plan can easily lead to seeing entirely new solution options. Rather than specific phases, these five components can be thought of as essential focus points for critical thinking in any problem solving activity. A conferencing system that supports critical thinking and inquiry should make these components of the inquiry process visible to the learners and support the learners in organizing their thinking around each component.

### **Elements of argumentation**

When we suggest that each of the above components of problem solving are a focus for critical thinking, we are in essence arguing that each is a focal point for argumentation. As previously discussed, critical thinking involves building an argument for a position with that argument considering evidence and counter arguments. In examining an argument, there are certain elements we look for as forming the foundation for critical thinking. Toulmin (see Toulmin, Rieke, & Janik, 1979), in one of the most established models of argumentation, identifies the elements as: claims, warrants, grounds, backing, and rebuttals. Voss and his colleagues (Voss, Fincher-Kiefer, Wiley, & Silfies, 1993; Voss & Means, 1991; Voss & Post, 1988) have used this framework in a series of studies of the informal reasoning of individuals about ill-structured problems. From a pedagogical perspective, it is unclear that a detailed system like Toulmin's would be useful. As the research discussed earlier (Kuhn, 1991; Perkins, 1992) suggests, the needs are so fundamental in this area that we would have a clear success if there was simply a consistent

consideration of evidence and counter-arguments for hypotheses. How often have we heard "Well that is what I think." as THE basis for taking a position — as if simply thinking it makes it the best solution.

In summary, a critical thinker will develop a strong argument in defining and interpreting the problem, in developing and evaluating solutions, in developing a plan based on a selected solution, and in reflecting on the learning outcomes. In each case, the essential elements of an argument that we will focus on are: hypotheses, counter-arguments, and evidence.

### **Quality**

Richard Paul (1993) has fervently argued that we have too often focused only on the structure of thinking — judging it as "good" if the structural components are present, e.g., an argument is good if the individual presents evidence. He argues that the word "critical" in critical reasoning refers to the quality of the reasoning. Hence, it is not just the structure and elements of the reasoning process that should be the focus, but also the quality of the argument and the sense it makes, e.g., the quality and credibility of the evidence source and how well it supports the argument. Educators must assess the quality of the individual's analysis of the problem, the quality of the counter arguments, and the quality of the evidence and the use of that evidence. Paul (1993) proposes such indicators as clarity, precision, specificity, plausibility, accuracy, relevancy, significance, logic, depth, breadth, completeness, adequacy, and consistency be used in judging the quality of critical reasoning. In the case of problem solving, Paul (1993) suggests the following indicators of quality to judge the student's problem solving:

- evaluating information for relevance
- constructing plausible inferences
- accurately identifying assumptions
- distinguishing relevant points of view
- distinguishing significant from insignificant information.

### **Collaboration**

Working with other people in the inquiry process is a context considerably different from individual inquiry and those differences must also be taken into account in the design of an electronic support system. In reflecting on our teaching in a learner-centered environment, our experiences in committee meetings, and in some recent pilot research on expert collaborative reasoning conducted in our laboratory,<sup>3</sup> it became evident to us that two distinct types of interactions occur in the collaborative problem solving process: 1) conversation and 2) issue-based discussion. In effect, the structure and quality of critical reasoning discussed in the previous sections is only a part of the collaborative process.

The foundation of group work, we propose, is conversation: we talk to each other to explore issues and seek common ground. Conversation is the general discussion between team members in which there is assessment of the group knowledge base and perspectives relevant to the problem. It is primarily "me"-centered — featuring a lot of "Here is what I think" types of comments made in response to an issue presented. In conversation, there is often a seeking of common ground in terms of meanings of statements and beliefs in the broad domain of the problem. Thus, topics arise as individuals think of them, rather than through an inquiry process. In these conversations there is a lot of talking past each other, with each individual wanting to make his or her views "known." As such,

---

<sup>3</sup> Conducted by Barbara Maynes and Heather Sugioka

conversation is exploratory rather than systematic. In addition, topics can change rapidly with little obvious link between topics and the most important topic or issue is what was brought up most recently — statements from five minutes earlier are, for the most part, lost.

Educators have typically eschewed this type of conversation among students. Students are criticized for talking past each other and for not systematically analyzing the issue. While we agree with this assessment, we want to argue that this sort of exploratory posturing is a necessary part of the collaborative problem-solving process. Reflection on virtually any committee or other collaborative problem-solving effort we have been involved in reveals that the free exploration of a range of topics, driven by personal interests and focused on "Here is what I think" statements, is an integral part of the activity regardless of the expertise of the participants.

We suggest that issues to be discussed and analyzed in detail arise out of these conversations and become the basis of more focused discussion and systematic analysis. In contrast to conversation, issue-based discussion is focused on moving to the development of the recommended solution or plan. Unlike the temporal flow of a conversation, the issue-based discussion is organized around important issues. The issue-based discussion is focused on hypotheses or issues relevant to the final product. In effect, the issue is examined in detail, with evidence, counter arguments, and alternative positions all being brought to bear. Unlike the conversation's exploratory nature, issue-based discussion is product focused. It is in an issue-based discussion that we attend to both the argumentation elements and quality of critical thinking. And also unlike conversation, Comments from earlier in the issue-based discussion remain relevant and are organized around the issues.

For all the reasons already discussed, we believe that a system to support critical thinking and inquiry must support both the conversation and the issue-based discussion. Further, we think that there is a need to link the two types of discussion so participants can review the context from which the issues arose and move back and forth between the issue discussion and the conversation. It is with these beliefs in mind that we are progressing toward the development of a conferencing system that supports critical thinking.

### **A Pedagogical Model for Collaborative Critical Inquiry**

Before turning to the design of conferencing systems, we will briefly examine one of the most widely discussed models for supporting collaborative inquiry in the classroom environment: problem based learning (Barrows, 1992, 1994; Savery & Duffy, 1996). The PBL framework, as described by Barrows, provides a well documented model for addressing many of the critical thinking goals described in the previous section. In this sense, the design of the PBL classroom environment can serve as a benchmark for the design of a distributed inquiry environment.

Problem based learning (PBL) is perhaps the most widely applied approach to teaching in which the focus of students activity is collaborative inquiry and the teacher is a model and coach for critical reasoning (Barrows, 1989; Barrows & Meyers, 1993; Milter & Stinson, 1995; Savery & Duffy, 1996). In PBL, students working with a facilitator in teams of about five are presented a problem or issue that they must analyze and gather data on with the goal of developing a response or recommended solution. There are two types of PBL sessions: (1) collaborative problem-solving sessions; and (2) self-directed learning sessions. Both kinds of sessions require learners to gather information in order to develop, reject, or defend hypotheses as well as explain alternative solutions. Our focus here is on the collaborative problem-solving sessions.

In the collaborative problem-solving session, the group members in a face-to-face collaborative environment, use what they know to generate and evaluate hypotheses and to determine what else they must learn to refine or evaluate their hypotheses. One member of the problem-solving team is often identified as the scribe who records on the white board the "important" points that are made in the conversation. The white board is divided into three parts: hypotheses, what we know, and learning issues (Savery & Duffy, 1996).

Using the framework for critical inquiry we have discussed above, there is both conversation and issue-based discussion in the problem solving session. The oral discussion is a conversation that is reasonably unstructured and moves in many directions. As in any meeting, the students discuss the problem and exchange perspectives on a range of issues and topics related to the problem. As discussion progresses, statements that the team considers "important" or recorded on the board as hypothesis/issue, data, or learning issue. It is these recorded statements that the team will return to and systematically analyze in putting together their proposed resolution of the problem. The use of the board provides the mechanism for moving from the temporal, conversation mode in the group discussion to an issue-based discussion where the PBL dialogue and the representation on the board are organized around hypotheses and key issues to be considered.

The teacher plays a critical role in facilitating the inquiry process. While there are alternative structures for the inquiry process, the most typical model as described by Barrows (1992) is a hypothetical-deductive approach. Hence, in moving into the issue-based discussion, the facilitator encourages students to generate hypotheses to be evaluated — rather than beginning by generating a list of what they know. As hypotheses are generated, evidence for evaluating the hypotheses (either known evidence or that which must be gathered) is identified. Unfortunately, PBL lacks a formal process or notation system for addressing the analysis of the problem, though such analysis does arise as part of the problem-solving process. PBL does, however, formalize the reflective process: the facilitator directs a post-problem discussion in which students evaluate both the process and the content that was learned.

The quality of critical thinking is modeled by the facilitator who asks important questions that model good reflection and critical thinking for the students. The facilitator has two goals in facilitating critical thinking. First there is the concern with the quality of the analysis. In this context the facilitator looks for the students to analyze the problem constraints and parameters, to provide or identify needed evidence related to hypotheses, to compare alternative hypotheses in terms of satisfying the goals, and to consider implications of proposed solutions. The questions the facilitator will model or coach if they do not develop naturally are:

- Do I know of evidence to support or refute that idea?
- What evidence should I seek?
- How does that relate to the problem/solution?
- Can we approach this problem another way?
- What do we have to do next ?
- What do we know so far?
- Can I organize what we have done so far?
  - What seems to be standing out in all of this?

It is also important for the learners to be able to understand whether or not they are active contributors to their group's conversation. While each individual should be asking the sorts of analytic questions outlined above, they should also be monitoring their understanding of what others are saying and be prepared to ask questions if clarification is necessary. Hence the questions the facilitator would look for or coach are ones like:

- Do I understand the terms that were used?
- How does that fit into the discussion?
  - What are the implications of that statement?

Conversations, as we noted and as we have all experienced, can go in many directions and certainly it can get off track. It is exploratory! One of the most effective strategies for developing order and focus out of the exploration is to attempt to summarize what has been discussed. Hence individuals and the group as a whole should periodically ask the questions:

- Where are we in relation to developing a solution?
  - What are the key ideas and issues we have been talking about?

As noted, the PBL model can provide benchmarks for the design of conferencing systems to support students at a distance. In particular, the PBL approach supports both exploratory conversation and issue based analysis -- and provides for moving back and forth between the two. There is also a focus on coaching the learners in effective problem solving skills and effective collaborative skills.

### **Technology to Support Collaborative Inquiry**

Scardamalia and Bereiter's (1991) computer supported intentional learning environment (CSILE) provides technological support for the issue based discussion in critical inquiry. CSILE was designed as a database system in which students conduct their inquiry in science. The original CSILE design used a simple database concept in which student could look at, for example, responses to a hypothesis that was made or see what contributions another student has made. Recent efforts have moved CSILE to a Web based environment in which all contributions to an inquiry are visible in a branching, web-like representation (Hewitt and Scardamalia, 1997; Hewitt, Scardamalia and Webb, 1997). A key feature of both the original and the Web based CSILE is that students are required to label their contribution to the inquiry. As an example, one set of the labels used in a CSILE-based research effort includes: "what I need to know", "what I need to understand", "high level question", "new learning", "plan", "my theory", "new experiment", "conclusion", and "synthesis" (Oshima, 1994). The labels serve to mentor students in the elements of inquiry in a way analogous to the facilitator in the PBL environment. That is, the students must think about how their entry contributes to the problem-solving effort.

CSILE research efforts have focused on the computer-based entries, i.e., the issue-based discussion. However, even in the Web-based applications, students are all in the same classroom. Thus we assume there is considerable oral conversation (as defined earlier) about the problems. We would hypothesize that this oral conversation is a critical component in the success of the more formal issue-based discussion that occurs in the CSILE system. Indeed, recent research from the CSILE lab (Hewitt, Web, and Rowley, 1997), in evaluating the effectiveness of the Web-based representation, describe considerable teacher-student and student-student face-to-face interaction that appears to be central to the successful use of CSILE. Thus the CSILE approach can extend the critical inquiry outside of the classroom in a distributed environment, but face-to-face contact in support of the conversational component of collaborative inquiry is essential to the success.

The Collaborative Visualization (CoVis) project (Edelson & O'Neill, 1994) at Northwestern University developed a Collaboratory Notebook that is similar in function to the CSILE system but is meant for use at a distance. In essence, students in different high schools use the Notebook as the vehicle for collaborative inquiry about a science problem. As with CSILE, CoVis students must label how their entry contributes to the inquiry. The

labels used in the Notebook include “Information”, “Commentary”, “Question”, “Conjecture”, “Evidence for”, “Evidence against”, “Plan”, and “Step in the plan” (Edelson & O’Neill, 1994). As with CSILE, this labeling process captures some of the coaching function of the facilitator in the PBL environment.

The Collaboratory Notebook is a relatively new product so there is not yet extensive data on its effectiveness. However, based on our earlier analysis, we would predict that students will find the Notebook difficult to use if there is no additional support for the conversation from which issue-based discussion arises. Fishman (personal communication, 1997), a project manager for the CoVis project, confirms our perspective in noting that, “When we designed the Collaboratory Notebook, we always believed that there would be other forms of communication surrounding its use, e.g. synchronous tools like Cruiser.”

While CoVis and CSILE are important products to the use of computer-based collaboration, they have distinct limitations if used in the context of distance learning. The lack of a tool to support conversation, for example, could cripple a problem-solving effort. There are, of course, dozens of Internet based conferencing systems. However, CoVis and CSILE are the only two that seem to make any attempt to address the pedagogical goals of supporting student inquiry. It is the limitations of these systems that has led us to the development of a new system.

## **Supporting Collaborative Inquiry at a Distance**

At this point, we turn our attention to the design of a networked conferencing system (including both tools and processes) which supports collaborative critical inquiry in any distributed environment: at a distance or as a supplement to face-to-face meetings. Consistent with the PBL framework and with most on-the-job problem solving teams, we are designing under the assumption that the system will be used by small groups (3–10 people) collaborating over a period of several weeks or more with little or no face-to-face communication. We are currently involved in the design and implementation of a portion of such a system that we refer to as ACT (Asynchronous Collaboration Tool), a WWW-hosted, asynchronous, text-based conferencing system. We are currently beta testing the two types of conferencing systems in ACT, but it should be recognized that all of the features outlined in this chapter have not yet been implemented. In particular, we have not yet built the links between the conferences; this is a work in progress.

### **Design goals.**

The ACT project is an attempt to use the theoretical underpinnings of critical inquiry already addressed in this chapter to drive the design of artifacts and processes which can be used to support small-group collaboration. Through this effort, we hope to better understand both the general nature of small-group inquiry and the practical considerations of conducting such inquiry in an asynchronous environment. Let us emphasize that while our design goals are focused on smoothly supporting those activities necessary to the process of critical inquiry, we are not attempting to make inquiry itself “effortless”. We firmly believe that critical thinking is an effortful, often difficult process and we seek to both encourage it through the inclusion of specific tools related to inquiry and support it through enabling focus on the process and structure of the inquiry.

Our design strategy can be distilled into four main goals:

### **Focus the user on problem solving.**

The process of critical inquiry must drive the basic design of the system. Students must be purposefully engaged in analyzing the problem, generating possible solutions, gathering evidence, and systematically evaluating the options. The various phases of the problem-solving process must be visible to the learner, and the analytic process in those phases must be at focus. Related discussions and off task discussions must be separated from the primary problem solving activity. By providing distinct areas for on-topic conversations and issue-based discussions, we attempt to make the problem-solving process itself a little less transparent to the user. The goal is to remain cognizant of the task at hand and indeed, guidance to the user should focus on the inquiry strategy at least as much as on the mechanics of using the application. The design goal is to lead the user towards a more focused dialogue in the groups' work areas.

### **Promote attention to and reflection on the argument and the goals.**

Helping students attend to the quality of an argument (their own or that of another) is critical to the learning process. Indeed, as the work of Paul (1993), Kuhn (1991), and others has demonstrated, children and adults remain largely unaware and inattentive to the quality of an argument — responses tend to be gut level reactions based on belief systems, not on hard evidence and logic. Using Schon's (1987) framework, our design goal is to promote both reflection-in-action and reflection-on-action. We want individuals to be reflective of the argument and their contribution to the argument in the action of making their contribution. If they are analyzing a problem they must be thoughtful of the way in which their contribution fits into an effective argument. But we also want the individuals to reflect on the ongoing discussion quite irrespective of their impending contribution. That is, as we discussed in the case of problem based learning, there is an important activity of taking stock of where the group is in the process. Whether it is a conversation about the problem or an analysis of the issues, we want encourage reflecting on the overall activity, asking and providing their answer to questions like "where are we now", "where should we be going next", "how well are we doing in our analysis/discussion". We want to permit the students to easily see what has happened and we want to facilitate their instantiating answers to questions like these as part of their participation in the inquiry.

### **Provide appropriate structures for each communication need.**

Collaborative inquiry is a complex activity involving a variety of types of interactions. Social conversation, for example, is, by its nature, unstructured and without explicit focus. Scientific discussion, on the other hand, is topically-organized and requires the ability to engage in very well-structured exchanges built around a common core of data and hypotheses. In between lies communication which addresses a problem holistically: brainstorming, problem definition, question-generation, etc. By examining the needs of each type of communication, we hope to build an electronic space appropriate for each type of interaction which can support the necessary organization without becoming a burden to the users as well as support movement of information between the spaces.

### **Support coaching by a facilitator.**

One of our central goals in this design effort is to help individuals develop effective critical thinking and inquiry skills. We have no doubt that a facilitator plays an essential role in this activity. In

essence, it simply is not possible to build all of the PBL facilitator responsibilities into a conferencing system. Thus, a design goal is to aid the facilitator or teacher in monitoring the problem solving activity in a way that will enhance his or her ability to offer constructive guidance on problem solving and critical thinking to the group as a whole and to individual participants.

### **Key design features**

We have identified two communication styles (conversation and issue-based discussion), several communication needs (social, administrative, brainstorming, in-depth hypothesis examination, etc.), and a desire to organize and archive ongoing inquiries for various purposes. At this point, we turn our attention to the creation of communication spaces which can support the activities associated with critical inquiry. There are seven key design features of ACT supporting the goals outlined above.

#### *1. Two conference structures.*

Based on our characterization of *conversation* and *issue-based discussion*, we provide two conference structures which can be used to provide the spaces necessary to support critical inquiry. By supporting both, we hope ACT can more readily cover the breadth of communication needs associated with small-group problem-solving.

*Conversation* is supported in a linear conference structure (see Figure 1). Messages are organized temporally (with the newest messages at the bottom of the document), reflecting the natural flow of a

## Team Blue: Orting Conversation

The city of Orting, WA (about a half hour from Tacoma) wants to build a new high-school to deal with and encourage population growth. County officials have refused the city's request to build because they feel the site chosen by the city is too hazardous: it sits on solidified mud flows from nearby Mt. Rainier, and any new flows could destroy the new school and everyone in it. The city council, however, feels that this is overly cautious considering that the entire city sits on this same mud flow.

You are members of an environmental consulting firm which has been hired by the Orting City Council, with the blessings of the county. You are asked to prepare a report which analyzes the issues surrounding the proposed school and makes a recommendation about how to proceed.

1. [What's a mud flow?](#) by JJ Sept. 4
2. [How close is Mt. Rainier?](#) by AB on Sept. 4
3. [How dangerous are mud flows?](#) by JR on Sept. 4
4. [Re: How close is Mt. Rainier](#) by JJ on Sept. 5
5. [Re: How dangerous are mud flows?](#) by AB on Sept. 5
6. [Why did the county refuse the site?](#) by TS on Sept. 5
7. [Re: How dangerous are mud flows?](#) by JR on Sept. 5
8. [Re: Why did the county refuse the site?](#) by JJ on Sept. 6
9. [Re: What's a mud flow?](#) by AB on Sept. 6
10. [We don't need a new school!](#) by TS on Sept. 6
11. [Re: We don't need a new school!](#) by AB on Sept. 6
12. Summary [How dangerous are mud flows?](#) by TS on Sept. 7
13. [Re: We don't need a new school!](#) by JR on Sept. 7 **new**
14. [More info on mud flows](#) by TS on Sept. 9 **new**

Figure 1. A Conversational Space. **Messages are arranged temporally to keep the focus on recent activities and the rapid advancement of ideas**

## Team Blue: Solution Analysis

The city of Orting, WA (about a half hour from Tacoma) wants to build a new high-school to deal with and encourage population growth. County officials have refused the city's request to build because they feel the site chosen by the city is too hazardous: it sits on solidified mud flows from nearby Mt. Rainier, and any new flows could destroy the new school and everyone in it. The city council, however, feels that this is overly cautious considering that the entire city sits on this same mud flow.

You are members of an environmental consulting firm which has been hired by the Orting City Council, with the blessings of the county. You are asked to prepare a report which analyzes the issues surrounding the proposed school and makes a recommendation about how to proceed.

**Hypothesis** [Mud flows make the area too dangerous](#) by AB Sept. 9

Question [What exactly does a mud flow do?](#) by JJ Sept. 10

Evidence [Pictures of CA mudflows](#) by AB Sept. 16

Evidence [Mudflows after Mt. St. Helens](#) by TS Sept. 22 **new**

Question [How fast do mudflows go?](#) by JJ Sept. 23 **new**

**Summary** [Mud flows](#) by JJ Sept. 23 **new**

**Hypothesis** [We could evacuate if need be](#) by JR Sept. 11

**Hypothesis** [We wouldn't have enough warning](#) by JJ Sept. 16

Question [How is a mudslide different than a mud flow?](#) by JR Sept. 13

Evidence [Mudslides and mud flows](#) by AB Sept. 21 **new**

Question [How much danger is too much?](#) by JJ Sept. 16

Question [How often does Orting get mud flows?](#) by JR Sept. 18

Evidence [Mud flows in WA](#) by TS Sept. 19

Figure 2. Issue-based Discussion. In the analytical discussion spaces, messages are organized by topic. Each message is also categorized along several dimensions to encourage in situ reflective thinking and allow for later searching and sorting.

face-to-face conversation and mirroring the organization of bulletin-board systems such as COW<sup>4</sup> or The Well<sup>5</sup>. By eliminating a deliberate structure, the linear conference promotes the quick exchange of ideas. Re-examination of a particular line of thought, however, is difficult. Linear conferences are suited to social and administrative chatter, brainstorming, holistic problem definition, and any other application which requires a safe, fast-paced environment.

*Issue-based discussion.* is supported through a hierarchical conference structure. Messages are organized by topic in an outline structure, with new messages indented under the post which inspired the reply. The need to pick a location in the hierarchy makes inserting a message a more reflective, effortful process, but should help students become more critically aware of their own contribution. The structure also makes it easy to review issues examining the discussion of an issue in a coherent manner and identifying which issues may need more attention. The hierarchical structure does make it more difficult to quickly locate new messages. While we do have a participant sensitive "new" message label for all unread message, the user must still scroll the discussion for the "new" labels. The hierarchical structure also reduces the use of more exploratory messages which don't have a well-defined place in the current hierarchy. But of course that is the intent of the design -- the exploratory discussion belongs in the conversation conference.

Let us emphasize that these two conferencing structures are distinct. Many conferencing systems have a single conference in which the user can reorganize messages to reflect the hierarchical relations or the temporal relations. We do not advocate that strategy since we see the design of the conference as an integral component of the type of activity. A temporal organization is simply not appropriate for an issue analysis process nor is an hierarchical arrangement appropriate to an exploratory conversation. Structurally misrepresenting the goals of the exchanges, in our view, can only lead to less effective if not frustrating and muddled exchanges.

## 2. *Issue Board*

A problem solving activity begins with a conversation and the analytical activity grows out of that conversation. This is not a linear process, of course, but rather there is movement back and forth between exploratory conversation and structured analysis. It is critical to support this interchange between conversation and analysis. While we have not yet built this component of the ACT system, our current view is to provide a transitory *issue board* -- much like a white board - onto which users can move messages from the conversation and from which they can export messages to the issue based discussion.

An alternative to the issue board design is to simply permit users to move messages from the conversation directly to the issue based conference. From an interface perspective that is certainly an easier task to accomplish. However, from the perspective of supporting effective inquiry, it seems to us that the immediate transfer will lead to a confusing issue based structure. Our strategy is to support users in identifying what in the current context are important hypotheses, issues, and evidence before these contributions get "lost" in the conversation. We think there is a need to let things evolve so that everyone can pause and reflect not only on the continued relevance of the message, but also on where it fits into the issue based conference. This will be especially important in the early stages of problem solving, when the exploratory conversation is

---

4 COW can be seen at <http://thecity.sfsu.edu/COW2/>

5 The Well can be found at <http://www.well.com/>

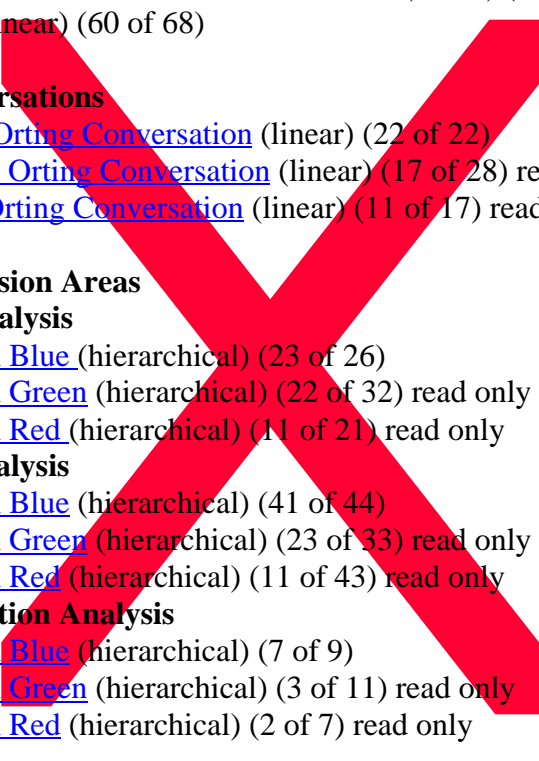
essential to developing a framework for an issue analysis. It is likely to become less important as the problem solving activity progresses.

### *3. Defined Communication spaces.*

The goal of focusing the users attention on the goals of the conferencing leads to a potentially complex conferencing space for the user. Clearly, this environment will require considerable user testing and revision. However as we have argued throughout this chapter, we feel it essential to focus the learners attention on the problem solving goal and to coach and promote high quality arguments.

When a user first logs in, she is presented with a list of links to the discussion spaces she is allowed to participate in. For most students, these will consist of those spaces that pertain to the entire class and associated small group or satellite conferences. Because the conferences are password protected, the student will typically only include the spaces that are specific to her group. An instructor may of course choose to allow students to keep track of the progress of other small groups, probably by offering the rest of the class read-only access to these conferences.

Included with each discussion space listed in the conversation and analysis areas is information showing how many total messages have been posted, how many have not yet been read, and what type of conference (linear or hierarchical) it is. This meta-information allows the user to quickly locate discussions relevant to her particular goal in contributing, showing her which conferences she can participate in and where new messages are located. Our current design of the interface for this discussion space is shown in Figure 3. The interface consists of general class conversation, problem focused conversation, and issue-based discussions on the key problem solving tasks.



## S104 Conference Listing

**General Class Conversations**

- [Administration and Course Announcements](#) (linear) (11 of 19)
- [S104 Café](#) (linear) (60 of 68)

**Small Team Conversations**

- [Team Blue: Orting Conversation](#) (linear) (22 of 22)
- [Team Green: Orting Conversation](#) (linear) (17 of 28) read only
- [Team Red: Orting Conversation](#) (linear) (11 of 17) read only

**Small Team Discussion Areas**

**Problem Analysis**

- [Team Blue](#) (hierarchical) (23 of 26)
- [Team Green](#) (hierarchical) (22 of 32) read only
- [Team Red](#) (hierarchical) (11 of 21) read only

**Solution Analysis**

- [Team Blue](#) (hierarchical) (41 of 44)
- [Team Green](#) (hierarchical) (23 of 33) read only
- [Team Red](#) (hierarchical) (11 of 43) read only

**Implementation Analysis**

- [Team Blue](#) (hierarchical) (7 of 9)
- [Team Green](#) (hierarchical) (3 of 11) read only
- [Team Red](#) (hierarchical) (2 of 7) read only

Figure 3. A sample of an opening screen. **Hypertext links are provided to each of the discussion spaces a user is subscribed to, along with information about number of messages and user permissions.**

Of course the conference headings are all definable and thus this structure can be modified or even eliminated. However, within the administrative system the prompted selection for conference headings are as shown in Figure 3. Furthermore, the default setting in the administration of ACT gives control for creation of new conferences to the system administrator (who may be the instructor or who may be a group member). In essence, while the system permits flexibility in designing the conferencing space, the default settings are designed to promote planful design of conferences that focus on the structure and process of problem solving.

*General class conversations* (see Figure 3) are set up as linear conversations available to all students. These conversations serve two purposes. First, they provide a social area in which students interact with each other and the instructor, resulting in general-interest and class discussion. Second, and more importantly, they provide spaces for students and instructors to address administrative issues such as syllabus changes and clarification, announcements of upcoming events, technical questions about the software being used, attempts to borrow a textbook, etc. This general class space helps prevent these kinds of issues from being included in the more structured work areas that focus on the specific problem or issue being worked on.

*Small-group conversations* are also linear conferences, but are restricted to the members of a specific work group. Here, we take advantage of the simplicity and low overhead of the conversational organization to support brainstorming, hypothesis-generation, looking at the problem holistically, and generating potential solutions. Clearly, students must feel safe to offer unsupported opinions and ideas in getting their issues on the table at any time. Consistent with the purpose of this problem solving oriented conversation area, and reflecting the familiar sequential nature of face-to-face conversation, a single conversational space is available for each group.

The *analytical discussion* areas in ACT are implemented as hierarchical conferences since they are designed to support intensive, in-depth discussion of specific topics. The administrative default setting are for three separate analysis spaces: problem analysis, solution analysis, and implementation analysis. All have the same structure, but each is dedicated to a different problem-solving activity and we anticipate that each will be most heavily used at different stages in the inquiry process. The user help system provides guidance to the users as to the goal for each analysis.

- **Problem Analysis.** This is an area reserved for discussion about the nature of the problem statement itself, so group members can come to consensus about what the problem is “really” asking. The goal of the problem analysis area is a succinct encapsulation of the problem being solved and the conditions and constraints which will inform decisions about picking and implementing a solution. Activity in this space will likely be intense at the beginning of the project and slowly taper off (without disappearing completely).
- **Solution Analysis.** Solution Analysis will be a primary focus and dominate the middle portion of the inquiry process. It is in this space that hypotheses are presented and criticized, evidence is gathered and interpreted, and solutions are proposed and slowly dissected by the group members. In most cases, the majority of analysis will take place in this space.
  - **Implementation Analysis.** This area is dedicated to the creation of an implementation of the agreed-upon solution strategy. Its use is most obvious in distance education (when students cannot get together face-to-face to discuss implementation issues) and when the problem

presented is in the hard or social sciences (as opposed to, for example, literary criticism). Implementation Analysis will obviously be empty at the very beginning of the problem-solving process, but will become more active as a solution is agreed upon and implementation details begin to surface.

<b>Type of Message</b>	<b>Content Source</b>	<b>Perceived Importance</b>
Hypothesis	Summary	Data
Important Point	Personal Opinion	Interesting Tangent
Evidence	Anecdote	Useful Thoughts
Learning Issue	Expert Opinion	Important Points
	Published Work	Critical Issues

Table 6. **Examples of potential message categories and labels.**

#### 4. *Required labeling of the elements of an argument.*

We use labels, much like those in CoVis (Edelson & O’Neill, 1994) and CSILE to focus students attention on their contribution to the problem solving (reflection-in-action) and to support their reflection on the on-going discussion. The labels are used differently in the two conference structures, reflecting the different goals of conversation and analysis.

The issue based analysis areas are the areas where the argument concerning the problem, solutions options, and implementation is a central focus Hence the goal here is to promote attention to the elements of the argument as one vehicle for judging the quality of the argument, for determining what is missing, and for determining how the user's post fits into the argument. We have already discussed how the issue based analysis areas are organized with these reflective activities in mind. The very structure of the conferences invites a student to ask the question, “Where does this information fit best within this discussion?”, thereby immediately initiating reflection-in-action.

We focus additional attention on these issues of argument structure and "my" contribution, by requiring users to categorize their post in terms of the contribution it makes. Rather than letting the student generate his or her own label, the label is selected from a menu. The list can be edited by the system administrator, thus reflecting particular needs of a problem solving activity or the particular framework of the instructor/facilitator. The default labels, shown in Table 6, reflect both the elements of effective argumentation as discussed earlier in this chapter and the requirements for effective collaboration, e.g., asking a question about someone's post. The narrow scope of many of the labels encourages the message to be succinct and focused, thereby preventing clutter and keeping the organization of the conference clean and easy to scan for relevant information.

The labels remain a highly visible part of the posts. A color coding and verbal label for each classification supports easy scanning of the structure of the argument developing, thus aiding the users to review the nature of the discussion regarding key issues, focusing in, for example, on the evidence provided or the counterproposals offered.

The conversational conferences are exploratory and involve brainstorming. Labeling each post in terms of its contribution would be cumbersome and counterproductive to the goals of the conference. Hence, we do not require labels in conversational conferences. Indeed, with one exception, we do not even make the labels available. That

exception is the label "summary". In our work with PBL we found that pausing to summarize progress in a conversation is very important in refocusing a groups efforts on key issues and in helping them to take stock of the progress and important points in the conversation. Thus, we encourage that a participant periodically assume responsibility for posting a summary of the conversational key points up to that point in time. In general, we find that the summary process is extremely useful for focusing attention on issues and paths and, since it remains very visible in the list of conference posts, it is easy to locate for review at any point in the conversation. .

##### 5. *Selective viewing of argument structure.*

All posts are stored in a database, making selective access to particular classes of posts possible. In contrast to systems that rearrange posts into hierarchical or temporal based sequences or which allow the user to specify the depth of the hierarchy displayed, in the next version of ACT we will permit users to present selected argument elements. Thus, for example, a user could ask to see only the *hypotheses* and *evidence* posts. The goal is to focus attention on and support users in their analysis of the argument structure. We also see this as a tool for the facilitator or instructor to monitor the developing arguments in ways that will facilitate coaching the teams.

##### 6. *Visual streamlining.*

One of the problems with conferencing systems is the small window into the conference: it is difficult to get a large perspective on the discussion. This problem is compounded by a clutter of messages that are primarily simply responses or acknowledgments to previous posts<sup>6</sup>. We have tried to provide an environment in which the user can easily see the structure of the argument by using three tools. First, the default presentation of the messages in a conference is one in which only the header information is presented, i.e., the classification of the message, the author, subject, and date. Thus the entry view is structural rather than a myopic view of the first message or two.

Two sorts of clutter are prevalent in asynchronous conferences: a tendency to simply acknowledge having read a message and the need to register agreement or disagreement (vote) on a proposal or statement in a message. In both cases, the screen is cluttered with a string of posts that are empty except to say "Thanks for your thoughts" or "I agree" and it is difficult to see the larger organization of the discussion. Of course, both types of responses are necessary. There is no greater frustration then making a post which you have thoughtfully constructed and wondering a week later if anyone has read what you had to say. We address the acknowledgment "I read this" need by providing a history of who read the post. The list of users (identified on login) who read the post is available by selecting history off of the menu bar. The history tool is not only a benefit to the conference participants but it also provides data for the instructor to assess level of participation by students.

We will address the voting issue by providing a "vote" response to message along with a component of the message header that displays the vote tally. Thus, rather than a vote resulting in a message below the one being responded to, the tally is simply displayed in the message header.

---

6. The clutter is especially evident in synchronous conferences where there is an administrative message acknowledging each persons entry and exit from the conference as well as their greeting to other participants. One significant problem in synchronous conferences is that the amount of this clutter sometimes exceeds the messages of substance.

### 7. *Post before viewing.*

One pedagogical strategy for promoting more effective collaboration in problem solving is begin by having each participant take a position on an issue. In essence, before an idea or a person dominates, each person should get a say. This could be done in the conversation mode where each person takes a position to start the discussion. It could also be in the issue based discussion where each person registers a response to the problem before considering alternatives. The problem could be academic -- come to some agreement on the key issues in the chapter and how they should be presented -- or it could be initial statements of key parameters of a non-academic, authentic problem.

Of course, the difficulty in achieving this pedagogical goal is that students will view other statements before posting their own and hence in many cases they will modify their thinking to be more in tune with what has already been stated. To aid instructors in better achieving this pedagogical goal we have provided an option of "post before viewing" that can be set for any conference. If this option is chosen, when users *first* enter a conference, they are required to post before they can see any of the messages or message headers that might already have been posted. This only happens on the first entry into the conference.

### **Current Status**

ACT is not a finished product. The discussion of design features identified what is completed and what is not. Importantly, the conversational and issue-based conferencing systems are complete (as a version 1.0) along with the requirement to label contributions. In essence the system features displayed in the Figures in this chapter are complete. Most importantly, the issue board, or some other mechanism for moving between conversation and issue based discussion is not complete. Since we firmly believe the design of the system must be consistent with the goals (conversation or issue analysis) of the discussion, we do not think either conferencing design alone is sufficient to support inquiry. And without the strategy for movement of ideas between conferences, the use of both types of conferences in an inquiry is cumbersome. So, our developmental priority is the design of the linkage between discussions.

We have used the issue analysis and the conversation discussion formats in several classes and we have used them in experimental contexts to understand the collaborative inquiry process and the difficulties in using one or the other discussion format as a vehicle for inquiry. The systems have been stable and effective. The interface clarity has been well received. However, as we anticipated, the use of just one system -- regardless of which one - to sustain collaborative inquiry at a distance, presents difficulties and frustrations when there is a mismatch between the particular goal (analysis or conversation) and the design of the conference.

### **Conclusion**

Asynchronous discussion environments like ACT afford us enormous pedagogical opportunities — opportunities that could not be realized in the classroom. In a traditional classroom, if there is even an opportunity for discussion, students must be bold and quick on their feet if they are to contribute. The asynchronous environment, however, affords students the time for thoughtful analysis, reflection, and composition as their discussion of an issue evolves. Furthermore, the discussions are products that the faculty member can review and grade and on which he can give feedback.

The difficulty is that too many designers of conferencing systems have had a simplistic view of discussion as simply talking. There has been little recognition of the different rhetorical structures and of the requirements for supporting those rhetorical structures in a text rather than oral mode. We have experimented informally with both conversation and issue-based discussion forums in our classes and have found that even experienced computer users have difficulties with each. The assignment in one case was solving an ill-structured problem — designing a course for a distributed learning environment. When students worked in the conversation environment, it was hard to stay focused. Certain individuals dominated and when an inferior idea was presented, there was an enormous amount of space taken up talking about why it was “bad.” Not surprisingly, the good ideas got lost. Furthermore, people were constantly talking past each other — posturing with their ideas, or simply trying to get an idea out that struck their fancy at the moment. Furthermore, there was a tendency to only look at “unread” messages — there was little motivation or time to venture back and sort through “old” conversations. And while there was prodding of the participants to stay focused and reminders of the ultimate goal, there was little, if any, sense of progress.

The issue-based forum provided a different set of difficulties. While there was a need for discussion, the hierarchical structure and labeling of the contribution was too constraining. No one knew how their contribution fit; especially when the discussion was just getting going or when there was simply an idea to share. Eventually conversation took place as a string of responses to one another — moving progressively inward in the hierarchy until someone decided to put their contribution down as a “new issue.” In effect, the issue-based structure was not usable in these earlier stages of problem solving.

There is no doubt that the system we are proposing and building is complex both in design and in use. Other conferencing systems provide for the ability to reorganize the conference posts so that they may be viewed grouped by author, by topic, or by time. We argue that this reorganizing strategy is inadequate. The structures are suited to different rhetorical goals and hence each will lead to or support different types of conversations. As noted above, it is awkward, at a minimum, to conduct a discussion when the conference structure is not consistent with the rhetorical goals.

There are a host of instructor tools that we have not discussed — tools essential to managing the class and assessing students. In the ACT environment, we have built or are building three support tools. First, there is a toggle to be able to see the messages in a discussion either all closed or all open. The former option permits us to see the structure and the participants in the discussion, while the latter permits efficient reading and evaluation of the contributions. Second, we provide an option where the instructor can see the contributions organized by author thereby enabling him to assess individual contributions. Finally, we will provide a history on each post, showing who has read it and thereby providing the instructor with yet another index of participation.

Finally, let us reemphasize that our goal in creating ACT is to promote critical thinking and, as we noted earlier, critical thinking is work. We have no doubt that if students are forced to focus on issues and consider how their contributions relate to these issues, they will find it to be substantial work. However, we are convinced that asynchronous conferencing environments offer the potential for realizing the intellectual goals of post-secondary education; to move beyond transmitting information and testing for facts and procedures. Asynchronous conferencing affords the opportunity for students to engage in critical thinking in the domains; to become participants in the intellectual discussions of the professions they are studying. It also affords the faculty the

opportunity to demand increasing intellectual rigor and to coach and assess students based on the quality of their thinking. It is with these goals foremost in our minds that we engage in the pedagogical based design of an asynchronous conferencing system.

## References

- American Association for the Advancement of Science (1993). *Benchmarks for science literacy: Project 2061*. Washington, DC: Author.
- Astin, A. (1993). *What matters in college*. San Francisco, CA: Jossey-Bass Publishers.
- Barrows, H. S. & Myers, A. C. (1993). *Problem-based learning in secondary schools*. Unpublished monograph. Springfield, IL: Problem-Based Learning Institute, Lanphier High School and Southern Illinois University Medical School.
- Barrows, H. S. (1992). *The tutorial process*. Springfield, IL: Southern Illinois University School of Medicine.
- Barrows, H. S. (1994). *Practice-based learning: Problem-based learning applied to medical education*. Springfield, IL: Southern Illinois University Medical School.
- Bereiter, C. (1992). Implications of Postmodernism for science, or, science as progressive discourse. *Educational Psychology*, 29, 3-12.
- Bransford, J. D., & Stein, B. S. (1993). *The ideal problem solver: a guide for improving thinking, learning, and creativity*. New York: W. H. Freeman.
- Braxton, J. M., Eimers, M. T., Bayer, A. E. (1996). The implications of teaching norms for the improvement of undergraduate education. *Journal of Higher Education*, 67, 603-625.
- Brooks, J., & Brooks, M. (1993). *In search of understanding: The case for constructivist classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development
- Cooper, J., Prescott, S., Cook, L., Smith, L., & Mueck, R. (1990). *Cooperative learning and college instruction*. CA: Trustees of the California State University.
- Dolence, M. G, and Norris, D. M. (1995). *Transforming Higher education: A vision for learning in the 21st century*. Ann Arbor, MI: Society for College and University Planning.
- Dolence, M. G., & Norris D.M. (1995). *Transforming higher education*. Ann Arbor MI: Society for College and University Planning.
- Edelson, D. C., & O'Neill, D. K. (1994). *The CoVis Collaboratory notebook: Computer support for scientific inquiry*. Paper presented at the annual meeting of the American Educational Research Association. New Orleans, LA.
- Ennis, R. H. (1962). A concept of critical thinking. *Harvard educational review* 32(1), 81-111. Cambridge, MA: Harvard University.
- Ennis, R. H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher*. 18(3), 4-10. Washington, D.C.: American Educational Research Association.
- Facione, P. A., Sanchez, Facione, N. C., & Gainer (1995). The disposition toward critical thinking. *Journal of general education* 44(1), 1-25. University Park, PA: Pennsylvania State University.
- Fischer, C. J., & Grant, G. E. (1983). Intellectual levels in the classroom. In C.L. Ellner and C.P. Barnes (Eds.) *Studies of college teaching*. (pp 47-60). Lexington, MA: D.C. Heath.
- H. Res. 1804 (Goals 2000: Educate America Act), 103d Cong., 2nd Sess., (1994).
- Harasim, L. (1990). *On-line education: Perspectives on a new environment*. NY: Praeger Publishers.
- Hewitt, J., & Scardamalia, M. (in press). Design principles for the support of distributed processes. *Educational Psychology Review*.
- Hewitt, J., Scardamalia, M., & Webb, J. (1997). Situative design issues for interactive learning environments: The problem of group coherence. In M. Scardamalia & C. Bereiter (Chairs) *Sociocognitive Design Issues for Interactive Learning Environments Across Diverse Knowledge Building Communities*. Symposium conducted at the Annual meeting of the American Educational Research Association, Chicago.

- Hewitt, J., Webb, J., & Rowley, P. (1994). *Student use of branching in a computer-supported discussion environment*. Poster session presented at the annual meeting of the American Educational Research Association, New Orleans.
- Hiltz, S. R. (in press). Impact of college-level courses via asynchronous learning networks: Some preliminary results. *Journal of Asynchronous Learning Networks*.
- Johnson, D. & Johnson, R. (1993). What we know about cooperative learning at the college level. *Cooperative Learning*, 13(3), 17-23.
- Kuhn, D. (1991). *The skills of argument*. New York: Cambridge University Press.
- Milner, R. G., & Stinson, J. E. (1993). Educating leaders for the new competitive environment. In G. Gijsselaers, S. Tempelaar, & S. Keizer (Eds.) *Educational innovation in economics and business administration: The case of problem-based learning*. London: Kluwer Academic Publishers.
- National Assessment of Educational Progress (1981). *Reading, thinking, and writing*. Princeton, NJ: Educational Testing Service.
- National Council of Teachers of Mathematics (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.
- Nunn, C. E. (1996). Discussion in the college classroom: Triangulating observation and survey results. *Journal of Higher Education*, 67, 23-26.
- Oblinger, D. G., & Maruyama, M. K. (1996). *Distributed learning*. (CAUSE Professional Paper Series, No. 14). Boulder, CO: CAUSE.
- Oshima, J. (1994) *Coordination of solo- and joint-plane of student activity in CSILE: Analysis from the perspective of activity theory by Leontiev and Engestrom*. Paper presented at the annual meeting of the American Educational Research Association. New Orleans, LA.
- Paul, R. (1993). *Critical thinking: What every person needs to survive in a rapidly changing world*. Santa Rosa, CA: Foundation for Critical Thinking.
- Perkins, D. (1992). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.) *Distributed cognition: Psychological and educational considerations*. New York: Cambridge University Press.
- Polya, G. (1957). *How to solve it: a new aspect of mathematical method*. Princeton, NJ: Princeton University Press.
- Roschelle, J. (1992). *Reflections on Dewey and technology for situated learning*. Paper presented at annual meeting of the American Educational Research Association, San Francisco, CA.
- Savery, J., & Duffy, T. (1996). Problem based learning: An instructional model and its constructivist framework. In B. Wilson (Ed.) *Constructivist learning environments: Case studies in instructional design* (pp. 135-148). Englewood Cliffs, NJ: Educational Technology Publications.
- 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, 37-68.
- 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, 37-68.
- Schon, D. A. (1987). *Educating the Reflective Practitioner: Toward a new design for teaching and learning in the professions*. San Francisco, CA: Jossey-Bass.
- Shank, G. D. (1987) Abductive strategies in educational research. *The American Journal of Semiotics*, 5, 275-290.
- Toulmin, S., Rieke, R., & Janik, A. (1979) *An introduction to reasoning*. New York: Macmillan.
- Voss, J. F., & Means, M. L. (1991). Learning to reason via instruction in argumentation. *Learning and Instruction*, 1(4), 337-350. New York: Pergamon Press.
- Voss, J. F., Fincher-Kiefer, R., Wiley, J., & Silfies, L. (1993) On the process of arguments. *Argumentation*, 7, 165-181

Voss, J.F., & Post, T. (1988). On the solving of ill-structured problems. In M. Chi, R. Glaser, and M. Farr (Eds.). *The nature of expertise*, Hillsdale NJ: Lawrence Erlbaum Associates.

Wallas, G. (1926). *The art of thought*, New York: Harcourt, Brace, and Company.

Wingspread Group on Higher Education (1993). *An American imperative*, Racine, WI: The Johnson Foundation.