Collaborative Knowledge Building: A Case Study

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What learning conditions are necessary to effectively support the knowledge-building enterprise in a learning community? To answer this question, the case-study method was employed to investigate collaborative knowledge building in a graduate level course designed to incorporate specific constructivist learning principles. These principles included (a) having a collective and authentic community goal to facilitate collaboration and engagement in the community, (b) using cooperative groups to provide for social negotiation and to promote multiple perspectives, (c) personally selecting of course readings and group decision-making to encourage ownership in learning, and (d) employing an integrated set of technology tools to archive the work of the community and facilitate communication. Results indicated that the instructional strategies designed into the course promoted collaborative knowledge building and the acquisition of key concepts through self-directed learning strategies. Results also pointed out the types of technological support required to implement an effective community of learners. A proposed set of guidelines is discussed to assist instructional designers in the design and development of collaborative, knowledge-building environments.

In an information society, knowledge moves into the forefront and becomes an object with which people work (Bowen, Bereiter, & Scardamalia, 1992). This suggests that students must become knowledge workers to function effectively in today's digital age. A constructivist philosophy of education may offer a means of teaching students to become knowledge workers, because constructivist practices are concerned with a learner's ability to use and manipulate information in authentic situations that have high relevance for the student (Lebow & Wager, 1994). Constructivist learning environments can provide opportunities for students to access, use, manipulate, and evaluate information using authentic problem-solving activities and strategies that focus on generative teaching and learning.

Making a shift toward a constructivist educational philosophy requires a change in focus from individual knowledge constructed singly to public knowledge jointly constructed by students (Brown, 1994; Brown & Campione, 1990; Scardamalia & Bereiter, 1992; Wenger, 1998). A constructivist orientation represents a fundamental change in education where the goal is to modify closed classrooms into knowledge-building communities that enable students to contribute to each others' learning through social construction of communal knowledge (Lebow, 1995).

Collaborative Knowledge-Building Communities

Knowledge-building communities arose from the idea that schools should be restructured as communities in which knowledge is constructed

as a collective goal (Scardamalia & Bereiter, 1994). The main focus of activities within these environments is on developing the collective knowledge base of the community and improving the problem-solving expertise of the learners. According to Lebow, Wager, Marks, and Gilbert (1996), a key principle guiding the design of knowledge-building communities is that the artifacts or objects produced by the learners are not simply passed in for a grade, but become public materials that support the goals of the community and its individual members. The resulting database of information archives the materials produced by the learners and is evidence of the community's advancing knowledge and expertise (Lebow et al., 1996).

This shift to a communal approach to learning changes the focus of the teaching and learning process. Bowen et al., (1992) characterized knowledge-building communities with four primary traits:

1. A focus on knowledge and the advancement of knowledge rather than tasks and projects.
2. A focus on problem solving rather than performance of routines.
3. Dynamic adaptation in which advances made by members of the learning community change the knowledge conditions requiring other members to readapt, resulting in continual progress.
4. Intellectual collaboration as members pool intellectual resources, making it possible for communities to solve larger problems than can individuals or small groups.

In the last decade, increasing attention has been paid to how computers can be used to support and facilitate learners as they interact and solve problems (Pea, 1994). This emerging interest is concerned with the design of tools that contribute to collective activity, and is characterized by authentic, collaborative work facilitated through the use of networked computers. The use of networked computers provides alternatives to traditional teaching and learning as we move from a single-classroom concept to the concept of a knowledge-building community of learners.

The computer supported intentional learning environment (CSILE), developed by Scardamalia and Bereiter (1992), is an example of a learning environment that incorporates the primary traits of knowledge-building communities and computers as tools. CSILE attempts to reform student achievement through a variety of methods, including collaborative learning, and a focus on group projects rather than lectures. The groups are given the tools to research a particular topic, solve problems associated with that topic, and present the information to their peers for review. Networked computers are used as the primary vehicle to promote collaborative knowledge building because they facilitate easy input and retrieval of information as well as providing a variety of communication features. Collaborative knowledge building engages students with the topic instead of leaving them on the outside as passive observers. Learners do not rely on simple memorization skills but must engage in higher-order thinking and inquiry as they arrive at a variety of solutions to a particular problem (Scardamalia & Bereiter, 1994).

In CSILE, knowledge building, rather than knowledge replication or retrieval, is the focus of student activity (Scardamalia & Bereiter, 1994). Knowledge in this environment is dynamic, and is changed and reconstructed over time. That is, students jointly build a body of knowledge represented by the community database that is an aggregate of the community rather than the individual.

More than 10 years of research on CSILE show that this approach can have a powerful impact on learning (Bereiter & Scardamalia, 1996; Scardamalia & Bereiter, 1996). Results of students in grades 5–6 using CSILE in all content areas suggested that students demonstrate a high level of knowledge building compared to non-CSILE students. Knowledge building in this context is the construction of new information stored in the communal database associated with the formulation of questions to help students notice what information to add to the database. Results also showed that a large proportion of the questions generated by CSILE students are rated as "challenging and considered worthy of research" by teachers and other adults (Bowen et al., 1992, p. 92).

Additional research with CSILE demon-

strates that students "greatly surpass students in ordinary classrooms on measures of depth of learning and reflection (awareness of what they have learned or need to learn), and understanding of learning itself" (Bowen et al., 1992, p. 282). Individual achievement, as measured by standardized tests, reflected increases in reading, language, and vocabulary for CSILE students compared to their non-CSILE counterparts (Scardamalia & Bereiter, 1992). Finally, Bowen et al., (1992) suggested that CSILE students appear to function beyond their years in solving problems and constructing knowledge at levels "one does not find in ordinary schools, regardless of the caliber of students they enroll" (p. 282).

Supporting Knowledge-Building Communities with Technology

How do computers function to facilitate knowledge building in a community of learners? Technology is typically discussed in terms of hardware and software. However, Jonassen (1995) posed the notion that technology is more than hardware and software and includes instructional strategies and teacher-student relations. Technology, in a constructivist learning environment, engages students in the enterprise of constructing knowledge and comprises tools that enable learners to build personal interpretations (Jonassen, 1995) by constructing and manipulating information (Perkins, 1991). In other words, technology comprises tools that extend cognitive functioning (Jonassen, 1995); that support, guide, and extend the thinking process (Derry & LaJoie, 1993; Hannafin, Land, & Oliver, 1999), and that engage the learner in critical thinking (Jonassen, 1995). Hannafin et al. presented a taxonomy of tool types according to the specific cognitive functions they support, and described integration tools as those that "help learners to link new with existing knowledge" (p. 129). Such tools also support knowledge representation, annotation links, and elaboration functions that help learners in "organizing ideas from a variety of perspectives and integrating them with personal knowledge" (Hannafin et al., p. 129). Because of these functions, integration tools should be particularly effective in supporting knowledge-building learning communities.

Jonassen (1999) argued further that tools used to support knowledge-building learning communities must also promote discourse among community members and open access to shared information. "Textualizing discourse among students makes their ideas appear to be as important as each other's and the instructor's comments" (Slatin, 1992, cited in Jonassen, 1999, p. 229).

Testing Design Features in a Technology-Supported, Knowledge-Building Environment

Our desire in this study was to integrate constructivist principles with the concept of learning communities in such a way as to yield design features that could be implemented and tested empirically. CSILE is unquestionably the most prominent example of a technology-supported learning community, but it has been employed almost entirely with children working on knowledge building over year-long spans of time. Indeed, virtually all of the research on learning communities that we are aware of has been conducted with school-age children (e.g., the collaboratory notebook—Edelson, Pea, & Gomez, 1996; the knowledge integration environment—Bell, Davis, & Linn, 1995). In addition, students using CSILE work on general, knowledge-building goals, creating theories and building explanations. Finally, until the advent of Web CSILE, the knowledge-building community was not networked to resources outside the classroom.

Construe©, Web software designed specifically for the purpose of supporting a knowledge-building learning community, was developed in 1996 for an application in higher education (Lebow et al., 1996), but it was not empirically validated. It therefore offered an opportunity to extend the findings on CSILE into the higher education arena with adult students. As school children must become knowledge workers to function in today's society, so must students in higher education, since most of them were educated under more traditional models of

schooling. Differing from CSILE, Construe is designed to manage a one-semester course, incorporates a database of articles that learners can easily access from the course Web site, and offers a means for students and the instructor to build links within the environment to resources outside of it. As an integration tool (Hannafin et al., 1999), it supports the ability of students to react to information, integrate new knowledge with personal knowledge, and view multiple perspectives. Construe also provides the open access to shared information that Jonassen (1999) indicated is critical in constructivist learning environments.

While Construe constituted the software aspect of a technology-supported learning community, we wanted to explore several constructivist instructional strategies as learning conditions to facilitate a community of learners. For instance, Wenger (1998) stated that "a source of community coherence is the negotiation of a joint enterprise" (p. 77). Combining that notion with the emphasis in constructivist learning environments on authentic tasks, we hypothesized that incorporating a collective and authentic community goal could be an effective instructional condition to facilitate the development of a learning community. A community project would be the joint enterprise within which both groups and individuals could negotiate more specific learning goals and tasks. The cooperative groups were also expected to promote multiple perspectives along with social negotiation of meaning. Finally, we wanted to encourage ownership in learning as a learning condition that may facilitate self-regulation in learners (Duffy & Cunningham, 1996; Lebow, 1995). To accomplish this, we incorporated an instructional strategy enabling learners to select course readings for personal interest and to meet the goals of their learning teams.

Purpose of the Study

The purpose of this study was therefore to investigate two research questions, one primary and one secondary. The primary question was: How effectively did the instructional conditions implemented within a graduate course dealing with alternate views of teaching and learning (known as Altviews) contribute to a collaborative knowledge-building enterprise? That is, what effects, if any, did a collective goal, cooperative groups, ownership in learning, and technology tools have on student acquisition and use of key concepts, self-regulation, and higher-order thinking? The secondary research question was: What instructional management issues arose at an individual, group, and community level and how were these issues resolved?

METHOD

The design of this research was a single case study focused on identifying and understanding the learning conditions that promote knowledge building in collaborative learning communities. According to Yin (1989), the case study as a research strategy is preferred for investigating *how* and *why* questions regarding a contemporary phenomenon occurring in a real-life context (p. 13). Once the case study's questions have been identified, the case is defined and sources of evidence from the case are determined that bear on the questions being asked.

The case was the Altviews course composed of 20 graduate students at Florida State University. The subunits of the case were individuals, groups, and the community as a whole. Data were collected over the span of an entire 15-week semester from students enrolled in the course, the course instructor, the course teaching assistant (who was also the primary researcher), and a student informant (identified at the beginning of the term and asked to take on the role of participant observer).

Learning Environment

The purposes of the Altviews course included introducing learners to the goals, methods, techniques, and theory base of a variety of recent and emerging models of learning, instruction, and instructional design. Because the course instructor wanted learners to experience, as much as possible, the theories and models they were

learning about, the course offered an ideal context for this research. Therefore, four instructional conditions were designed into the course, each with a specific function as indicated by the literature on learning communities:

1. Having a collective and authentic community goal to support collaboration and engagement in the community. Throughout the semester, the class was engaged as a learning community in the design of a charter school whose guiding principles were based on the knowledge base (articles) of the Altviews course and outside resources added by class members. This project was designed by the researcher and instructor as a vehicle to promote collaboration and knowledge building. It was authentic for the students enrolled in the Altviews course in the sense that charter schools have evidenced a great deal of interest in Florida education, generally, and the local area, specifically. Debates are common in the students' academic programs regarding how instructional design principles might inform public education, and the project offered a concrete opportunity to put these ideas into practice.

2. Using cooperative groups to provide for social negotiation and to promote multiple perspectives. Six learning groups were formed (four of the groups were composed of three students, and two—Planning, and Apprenticeship—had four students) to discuss course readings, cooperate on developing the community project, and create a concept map. To accomplish the course project, class members negotiated tasks related to (a) Planning, (b) Learning Objectives and Curricula A and B, (c) Learning Environment, (d) Community Integration, and (e) Apprenticeship and Extra Curricular Activities. These became the basis for the six learning groups (two groups tackled Learning Objectives and Curricula). Participants indicated their preferences for working on a particular set of tasks, and the instructor used this information to assign them to learning groups. These were the chosen roles of the learning groups to achieve the collective goal of developing a charter school. Additional group responsibilities included the development of a concept map using Inspiration™ software to pictorially represent the relations among diverse concepts taken from the readings.

3. Personally selecting course readings and group decision-making to encourage ownership and responsibility in learning. Based on the tasks negotiated within each learning group, individual members of the group selected readings from a database of articles and sought outside resources of interest to them and their group. The articles included recent publications on topics such as constructivist theory, cooperative learning, problem-based learning, technology as tools, assessment from a constructivist perspective, and learning communities, among others. The articles also represented both empirical research and conceptual or theoretical discussions. Students wrote reactions to the articles they read, selected and defined key concepts, and abstracted excerpts from the articles to illustrate defined concepts. Individuals also wrote confidential reports to the instructor twice during the semester reporting on the quality of their learning experiences. Finally, individuals submitted final course reflections evaluating the effectiveness of the instructional strategies incorporated into the course.

4. Employing technology tools to archive the work of the community and facilitate communication. The primary tool used to promote the collaborative effort of the community, Construe, was originally designed and developed during the Spring semester, 1996, for a distance learning class. It is software developed collaboratively by Florida State University and N.C.R. Corporation for the purpose of facilitating the development and management of learning environments over the World Wide Web (WWW). A key principle in the design of Construe is that the artifacts or objects produced by the community have value. The knowledge objects that members create and appropriate from the outside world become public materials supporting the goals of the community and its individual members. The accumulating database produced by the participants is evidence of the community's advancing knowledge (Lebow et al., 1996). Thus, individuals and groups "published" all of their work on the course's Construe Web site,

which also contained the article database. In addition, from within the site, class members could send e-mail messages to another individual, a selected group, or the entire class.

Collectively, these instructional conditions were expected to contribute to the effectiveness of the learning community through enhancing acquisition and use of key concepts, promoting self-regulation, and facilitating knowledge building.

Data Collection

Ten different data sources were used to collect evidence for this investigation. Some of the data sources were expected to bear on more than one research question, as shown in Table 1. In this section, the data sources are described. Each data source is presented along with the means by which data were collected from that source and the information each source was expected to yield.

Figure 1 displays what happened in the Altviews course over the 15-week semester. The instructional conditions that were the focus of the study had been incorporated into the design of the course prior to the beginning of the semester. Thus, during the semester, the course proceeded according to its normal calendar, the only addition being the background survey administered in the first week. Artifacts of the course served as the primary sources of data.

Background survey

Questions on participants' educational background, familiarity with the technology used in the course, and professional goals and experiences comprised the Background Survey, which

Table 1 ☐ Relevant data sources for the two research questions

Data Sources	*Background Survey*	*Confidential Reports*	*Reading Reactions*	*Concept Definition & Excerpt*	*Concept Maps*	*Teaching Assistant Journal*	*Instructor Journal*	*Participant Observer Journal*	*Final Course Reflections*	*Final Project*
How effective were the instructional conditions in promoting knowledge building?										
Anticipated Results										
Acquisition & use of key concepts				×	×		×	×	×	×
Student self-regulation		×	×				×	×	×	
Higher-order thinking				×						
Instructional Conditions										
Collective purpose	×					×	×	×	×	×
Cooperative groups		×	×	×	×			×	×	×
Ownership in learning	×	×	×	×				×	×	
Tools		×				×	×	×	×	
What management issues arose as the instructional conditions were implemented and how were they resolved?										
Management issues		×				×	×	×	×	

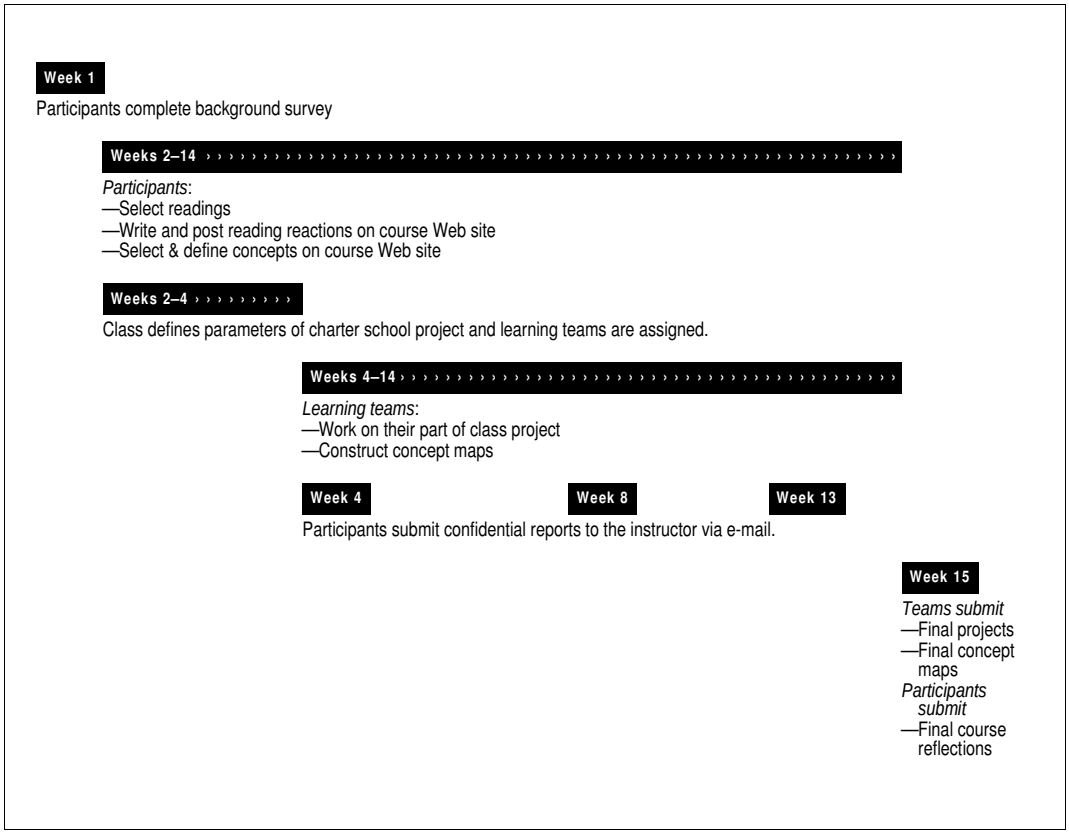
included the voluntary agreement of class members to participate in the study. The background survey also provided information on the participant's name, degree program or major, level of computer expertise, and experience or interest in educational reform. It was expected that initial differences among participants might influence their reaction to the design features incorporated into the course.

Reading reactions

Reading reactions consisted of essays written and posted to the course Web site by students in response to the articles they selected and read. Students were instructed to react not only to a reading but also to any reactions already posted by other participants. On a Web form under headings for each, students entered their "gut reactions," "big ideas," "implications for teaching and learning," and "nagging questions." Class members posted reading reactions at their own rate, but they were encouraged to write and post at least one each week.

The purpose of the reading reactions was to promote generation of knowledge rather than replication of knowledge. The quantity and quality of the participants' reading choices and associated reactions reflected their contributions to the knowledge base and the knowledge-building effort of the community. The reading reactions were downloaded from the Web site and expected to include appropriate use of the concepts associated with the individual's role in the collective goal of the community, personal attitudes and values concerning learning and instruction, and critical evaluation of models and theories studied throughout the semester.

Figure 1 □ Course activities and data collection in Altviews over the 15-week semester



Confidential reports

Twice during the semester, students submitted confidential reports, in which they reflected on their learning and course process. Students e-mailed their confidential reports directly to the instructor, who shared them with the class *only* with approval of the student submitting the report. The purpose of the confidential reports was to provide information on the overall quality of the learning experience, how well each learning group was functioning, perceptions about the process of the community project, and any suggestions for change or improvement. This data source provided information on individual, group, and community issues, and evidence for how well the individual was adapting to the instructional conditions related to the learning community. A file was created for each learning group, with the confidential reports and instructor's comments in response to the reports arranged in sequence by date.

Concept definitions and excerpts

The purpose of this data source was to provide information on how well the participants understood the articles and the associated concepts derived from the articles. The Web site was populated with 20 key concepts prior to the beginning of the course. These initial 20 concepts formed the foundation of the knowledge base. Concepts were added by the participants throughout the semester based on the readings they chose and their role in accomplishing the collective goal of the community. Participants generated concept definitions and linked excerpts from the readings based on their understanding of the article; they were not to quote a definition directly from an article or repeat a previously entered definition. For example, one student added the concept *abduction* to the knowledge base. She described abduction as "the process of making connections from one context to another." Her excerpt included this explanation:

> While biases and preferences often impeded understanding, these mental idiosyncrasies may also serve as powerful, if quirky and personal, guides to solutions. C.S. Peirce coined a word to express the imaginative mode of reasoning involved in such mental leaping.

All the concepts were archived and downloaded from the Web site by learning group.

Concept maps

In their learning groups, participants generated concept maps using Inspiration™ software. The map's organization and the concepts selected by the participants were directly associated with their chosen role in achieving the collective goal. Learning groups submitted concept maps in hard copy and in electronic form, either on disk or posted to the Web site, at the end of the semester. The purpose of concept maps was to provide information on each group's understanding of relations among the diverse concepts. The maps were dynamic, and changed over the semester relative to each group's role in accomplishing the collective purpose. The final versions of the concept maps were printed for examination and comparison.

Final project reports

Learning teams wrote final project reports at the end of the semester describing their team's contribution to the collective goal (development of a charter school), which they published on the course Web site. All records were archived in and downloaded from the Web site. The purpose of this data source was to provide information on individual and group effort for achieving the collective purpose of the community. The reports were expected to show a direct connection to the concept maps and the collective purpose of the community.

Journals of the teaching assistant-researcher, instructor, and student informant

Throughout the semester, the teaching assistant-researcher, instructor, and student informant kept journals of their reflections on class activities, administrative issues, and the course structure in general. These journals also provided information on the minutes of meetings from the planning stages of the course to

the end of the semester. These meetings among the instructor, teaching assistant-researcher, and participant observer were held on a weekly basis. The notes summarized the wide range of issues that arose from week to week and were kept in a loose-leaf notebook and then transferred to a word processing file.

Participants' final course reflections

Participants were asked to respond to a set of questions asking for specific feedback on aspects of the course. Participant reflections were solicited via a set of questions e-mailed to them at the end of the semester. The purpose of this data source was for the student to provide a critical evaluation of the theoretical and practical considerations of learning, instruction, and instructional design models designed into the Altviews course. Participants reflected on course experiences and evaluated the effectiveness of the teaching and learning models used. Specific questions focused on the nature and degree of individual and group collaboration relative to the instructional conditions of the course. This data source provided information on participants' personal attitudes and values concerning learning and instruction, and critical evaluation of models and theories studied throughout the semester. The final course reflections were retrieved in electronic form from the instructor.

Data Analysis

The first step in data analysis was to transfer to word processing files all of the data archived on the course Web site or sent electronically to the instructor. Electronic files were also created for the data contained on the background survey; the journals kept by the instructor, teaching assistant-researcher, and student informant; confidential reports; and the final course reflections. Once electronic files existed for every data source, the data relating to each source had to be aggregated, summarized, and in some cases, coded.

For instance, information from the background surveys was summarized by individual, resulting in a profile for each participant. Responses to the confidential reports and final course reflection questions were also summarized by individual. Concept definitions and excerpts were summarized by learning group, with the researcher recording how many concepts defined by the group came from the original 20 included in the Construe database, how many came from articles in the database but not included in the original concept list, and how many came from articles and resources outside the course Web site altogether. Concept definitions were also examined for accuracy. Concept maps were considered in relation to the concepts identified and defined by each group. Individual links between concepts and the overall structure of the map were examined to identify patterns or gaps in connections among concepts and their connection to the final project.

Then reading reactions, confidential reports, and journals were coded following the same basic procedure. First, each document was read and codes relevant to the research questions were identified and marked on a printed copy. For instance, the first question concerned how effectively the instructional conditions designed into Altviews contributed to the knowledge-building enterprise of the community. The reading reactions were designed to serve as a scaffold to promote knowledge building and higher-order thinking associated with the theory base supporting alternate views of teaching and learning. It was also expected that participants would read and refer to the reading reactions of others as they constructed their own responses to a particular article. Thus, codes emerged from the reading reactions data pertaining to students' *reflection* on what they read, their *referencing* other resources, and evidence of *higher-order thinking* (e.g., combining ideas from several readings to offer a new perspective). Within each of these three categories, codes were further refined based on what the data revealed. Table 2 displays the final set of codes and code definitions that resulted from the analysis of reading reactions.

To determine the reliability of coding, the researcher asked the instructor to use the coding scheme that emerged in the analysis to code a

Table 2 ☐ Reading reaction categories, codes, and definitions

Reflection Category
Surface Reflection (SR)—ties into personal experience (relevancy) without offering any new perspective
Deep Reflection (DR)—ties newly acquired information from the readings into previous experience and restructures based on individual perspective
Referencing Category
Reference Participant (RP)—references another participant (recognizes value of the work of the community)
Reference Participant Plus (RP+)—references another participant and adds another perspective
Reference Author (RA)—references another author (recognizes the value of the readings)
Reference Author Plus (RA+)—references another author and adds another perspective
Reference Course (RC)—references course goals or structure (recognizes value and relevancy of course goals or structure)
Reference Course Plus (RC+)—references course goals or structure and adds another perspective
Higher-Order–Thinking Category
Knowledge Synthesis (KS)—combines ideas together from the readings and restructures new information to provide a different perspective
Critical Analysis (CA)—critically analyzes author, article, or participant; agrees or disagrees and provides rationale, identifies knowledge gap, offers suggestion, opinion, or new approach to the problem

reading reaction she had coded previously. There was almost complete agreement between the two; the few areas of disagreement were discussed and the codes modified until both parties were satisfied with the result.Thereafter, the researcher asked the instructor to review codes and examples from the data that illustrated those codes every time a new code became apparent.

When all the individual data sources had been coded and recorded, the sheer amount of data precluded an in-depth examination of all class members. Instead, the results of six participants were investigated in depth through the use of a time-ordered metamatrix (Miles & Huberman, 1994) that displayed the sources of data over a 15-week semester for these six people. The six were chosen to reflect the diversity of students in the course with respect to completion of assignments and satisfaction with course goals and structure. That is, two completed all assignments and expressed high satisfaction with the course, two completed most of the assignments and expressed moderate satisfaction with the course, and two completed only a few of the assignments and expressed low satisfaction with the course.

From the time-ordered metamatrix, patterns in the data were sought to answer the primary and secondary research questions. Thus, data sources were examined first for evidence of the effects the instructional conditions may have had on acquisition and use of key concepts, self-regulation, and higher-order thinking. Then, issues related to course management were identified and evidence sought in the data sources concerning their resolution.

For example, with regard to the primary question, an issue related to the cooperative groups arose in several of the data sources including confidential reports and final course reflections. Specifically, comments referred to how a group's functioning may have affected the students' knowledge building (individual and community-wide), self-regulation, and the achievement of the collective goal. One student was not completing his work on time and felt he was not supporting either his group or the community. Failing to do the reading reactions in a timely way affected his group's ability to complete work on the concept maps and the community's ability to use what he was learning to advance its goals . The recurrence of these types of comments indicated the development of a pattern.

RESULTS AND DISCUSSION

The purpose of this study was to implement and evaluate the effectiveness of specific instructional conditions designed to facilitate knowledge building in a community of learners. This section begins with a brief profile of the par-

ticipants from whom data were investigated in detail and then presents the effects of the instructional conditions that were incorporated into Altviews. The effectiveness of the instructional conditions and how they supported collaborative knowledge building as well as classroom management issues are discussed in terms of the key constructivist principles implemented in the Altviews learning environment. We chose this organizational structure to discuss the results because our focus is on *how* the conditions worked, not just whether they succeeded in having an effect. Although we use these principles as a guiding framework for presenting and discussing specific results, our findings reflect synergistic effects that are hard to attribute to one or another learning condition alone. This recalls Bell and Winn's (2000) argument that successful classroom interventions involving technology tools result in outcomes that are "systemic effects of the package, not of particular components in the intervention" (p. 141). Finally, the section closes with a brief discussion of implications for instructional design and suggestions for design guidelines.

Participants

The class comprised 20 master's and doctoral students. Half of the class was in the Instructional Design program. The remaining students included majors in Art and Social Studies Education, and Human Sciences. The computer expertise varied, but all students had basic computer skills. This was important as we did not want the lack of computer skills to interfere with the quality of learning. Six participants were chosen for in-depth investigation of their data. All names are pseudonyms.

Warren and Mary completed all assignments on time and expressed a high level of satisfaction with the course in their final course reflections. Warren is a graduate student in communication research and a high-level computer user, based on his familiarity with IBM and Mac platforms, e-mail, WWW, and a variety of other software programs. Warren hopes to design Web-based education programs upon graduation. Mary is a doctoral student in elementary education. She is a medium computer user and hopes to be involved with teacher training at the university level.

Two students, Chris and Carol, completed most of their assignments on time and expressed both positive and negative comments about the course. Chris is a graduate student in instructional systems and a high-level computer user. He hopes to apply instructional design concepts and theories to performance problems in higher education. Carol is a master's student in instructional systems and a medium-level computer user. She has some familiarity with PC platforms and limited experience with e-mail and the WWW.

Finally, Matt and Julie were two students who did not complete all their assignments and had mostly negative comments about their satisfaction with the course. Matt is a doctoral student in instructional systems and a high-level computer user. His professional goals include working in a corporate environment. Julie is a master's student in instructional systems and a high-level computer user. Julie hopes to develop multimedia programs for corporate environments upon graduation.

Space considerations preclude the inclusion of comments from all six participants for each of the constructivist principles discussed in the following sections. Comments were selected primarily from Warren, Mary, Matt, and Julie because they provided the most meaningful insights into the Altviews learning environment.

Collective and Authentic Community Goal

According to Wenger (1998), a knowledge community must have three interacting dimensions: (a) mutual engagement, (b) a joint enterprise, and (c) a shared repertoire. In this study, a collective and authentic community goal was used as a means of implementing the three dimensions. The problem, creation of a charter school, was expected to provide the joint enterprise that would mutually engage participants. The shared repertoire was the Construe, Web site, which contained some resources and provided the structure for participants to add information that would support community efforts.

The final project reports constituted the community's attempt toward achievement of the collective goal, that is, development of the charter school (which the class named Synergy Center). Producing the reports was the last activity accomplished in Altviews, and it brought together all the readings, concepts, group work, and class discussions. Class members, together with the instructor and teaching assistant-researcher, negotiated six teams based on functional roles the class identified as necessary for achieving the goal. The teams thus became (a) Planning, (b) and (c) Learning Objectives Curricula A & B (two teams), (d) Learning Environment, (e) Community Integration, and (f) Apprenticeships. Once the teams were in place, individuals began selecting readings based on their team's role, and each group designed a concept map that was used to support its role in accomplishing the collective goal.

For instance, the Planning team went outside the articles database to incorporate Kaufman's organizational elements model (Kaufman & Grise, 1995) as a needs assessment tool to identify gaps between what is and what should be concerning Synergy Center. Likewise, the Community Integration team decided to emphasize the life-long learner as the focus of its concepts. In the final project report, that team wrote, "a Synergy Center learner will develop into an adult learner, who in turn is a life-long learner." The primary concepts identified to support this focus were theories of teaching and learning, problem-based learning, authentic achievement, and knowledge-building community. This team's concept map also included detailed key ideas, such as cooperative learning, novice to expert transition, modeling, authentic assessment, and mentoring. For each of the concepts on the map, the team provided a definition, related the concept to prominent aspects of the community goal as well as its own goal of producing a life-long learner, suggested an evaluation strategy regarding the concept, and included links to related Web sites.

Evidence from the team concept maps indicated that all groups used key concepts that they appropriated from sources outside their teams. In addition, it was apparent from Construe's tracking of who posted concept definitions that all participants, rather than only a few individuals in the community, contributed to this collaborative effort.

Although community members had a joint enterprise in achieving the collective goal, and a shared repertoire in the course Web site, it is not so apparent that the collective goal encouraged mutual engagement (Wenger, 1998). The development of the charter school required intense interaction across groups to share ideas and strategies, and ensure a cohesive approach to this problem-solving exercise. The interchange among groups was weak, however, with almost no exchange of ideas outside of class. One possible reason for this was Construe's communicative function, which enabled class members to send e-mail messages only to the community, a team, or an individual. Warren said, for example, that he rarely contacted any other participants even though he wanted to because Construe did not support quick interchange of ideas in the same way a bulletin board would.

Participants repeatedly recognized, in their confidential reports and in class, that the class was not functioning so much like a community as a group of teams. Julie offered this suggestion to improve the quality of cross-group interchange: "Some mechanism [should] be put in place to allow more exchange of information between functional groups and tasks." Late in the semester, a "jigsaw" routine was implemented during class in an attempt to create more mutual engagement among members of the community. Teams met outside of class to determine what progress they wanted to communicate to other teams. Then, during class, teams regrouped in jigsaw fashion to share their reports with members of other teams. Unfortunately, this occurred too late in the semester to solve the problem of mutual engagement and was more of an after-the-fact, "Band-Aid" solution. Community interchange is critical for collaborative knowledge-building communities; provisions should have been made from the beginning to ensure this effort was supported. As useful as Construe was for the individuals within a team, it fell short as a community communication tool. Access to a listserve, chat room, or bulletin board for posting issues related to course assignments,

ideas, technology problems, and other items of interest might have promoted greater interaction across groups.

Finally, it appears as if the charter school development was not as authentic a task or problem as we originally thought. That is, it did not bring the community together as a coherent whole for all groups but instead appealed to some groups and individuals more than others. Julie stated that the collective goal ". . . was not as effective as we hoped. Once we split into our respective groups, the collective purpose was lost because most were only concerned about the issues directly affecting their own functional area." Another student reported in a confidential report that she had been excited at first by the idea of developing a charter school. But the more she and her team got into it, the less interested she became, primarily because she did not view her future work as an instructional designer to be related in any way to schools. Thus, although we had a collective goal, we did not have a shared community vision in which all groups worked together in a collective way. For some, this whole-class problem-solving activity turned into busy work, and just another project to complete before the semester ended.

Cooperative Groups and Collaborative Activity

Discourse is the heart of collaborative knowledge-building communities (Scardamalia & Bereiter, 1994). The use of cooperative groups in Altviews was designed to support knowledge-building discourse and facilitate collaborative activity. The students worked at an individual level reading and reacting to articles and identifying key concepts. Then, individuals brought their personal understandings of the readings and concepts to the team where the concept mapping activity prompted them to confront and resolve multiple perspectives and negotiate a common understanding with respect to the team's role in accomplishing the collective goal.

Participant responses to the final course reflections provided insight into their perceptions of collaboration. In several questions, students were asked to comment on the extent to which they used other people's work, either in writing their own reading reactions or bringing ideas to the team. Warren commented that collaborative effort "depended on the time element." Reading reactions were time intensive, because students were instructed to read all the reactions and consider them before posting their own. Some students reported that they found the reading reactions beneficial and read all previous reactions before posting their own. This was supported by the analysis of reading reactions, which revealed a substantial number of references to the work of others. However, some of the students felt that "reacting to the reactions" resulted in repetition of effort. After three or four responses to an article, the main ideas and concepts are usually identified. We could have restricted the number of responses, but this would have limited the reading selections for the community and the level of self-direction we were trying to encourage, a point which will be revisited in the next section.

Warren completed all the reading reactions even though he had a large gap of inactivity in the middle of the semester. His first confidential report indicated satisfaction with the learning experience. "I find the interactions excellent. The ideas and concepts are first-rate . . . I get a sense we are forming a cohesive group of like-minded individuals embarking on a shared goal." Midway through the semester, however, Warren experienced a personal crisis that prevented him from completing course assignments on schedule, which in turn affected the collaboration in his team and the community. He expressed concern about his inability to complete class assignments on time and reaffirmed his responsibility in an e-mail message to the entire class.

> When I agreed to be part of this community of learners, I accepted the responsibility to contribute to the knowledge base. I have felt for sometime that I was not and am not contributing my fair share. I want to let all of you know that I take this opportunity seriously and am reaffirming my commitment.

After this note to the community, Warren's final report indicated a lack of leadership on his team, ". . . no leader has emerged . . . causing a drift ... we haven't fused into a working unit."

His final course reflection indicated the course structure supported "isolationist activities" better than it did collaborative activity:

> I was able to access the readings very easily and the reactions of my fellow peers. I even liked (although it scared me) the listings of my accomplishments . . . The web-structure allowed me to access the course even when I wasn't in town . . . How liberating . . . it was wonderful.

But, again in Warren's words, "As well as Construe supported me working alone, it did not support me working in a group."

Like Warren, Mary had a positive view of her learning experience early in the semester. In her first confidential report, she expressed positive comments for her overall learning experience. "I am thoroughly enjoying this course . . . I am learning and exploring new material and ideas . . . and exposed to a new model of teaching. I am very excited about both of these aspects of the course." By the end of the semester, however, Mary's experience was deteriorating: ". . . my individual experience had declined . . . due to the fact that most of my effort in the last few weeks has been expended on the group project." These comments are indicative of some of the problems Mary's group experienced that degraded her learning experience.

Mary wrote a letter to the instructor expressing her concerns about her group. One of her group members had a life-threatening illness and was missing group meetings. "I'm concerned because of his illness . . . because he is having surgery." Another group member missed a class and a group meeting, and Mary stated, "I'm concerned that our group is not working well together . . . I'm disappointed in our group's effort."

Mary's group had worked out a plan to include a peer review of each other's work, put all the pieces together, and then do a final review on the whole product. However, this was not accomplished in a timely manner, and Mary's reaction was that "I feel the sections are not the result of group collaborative effort . . . rather they are individual products."

Warren and Mary appeared to experience the feeling of being part of a larger group, and they understood the quality of their learning experience was dependent on the work of others. They also accepted their own responsibilities to the community. Other students seemed to stay at the group level and were more concerned with their individual learning than that of the community. Those students who failed to complete their reactions in a timely manner and didn't feel empowered to regulate their own learning were somewhat lost in a self-directed learning environment. It appears as if the level of self-regulation was limited to only those students who were engaged at a community level and felt part of a larger group.

Matt, for instance, described Construe as a constraint and stated in his second confidential report, "The internet-based aspect of the class made me feel alienated from other class members. Writing does not come natural like speaking . . . posting articles cannot be a substitute for oral communication." Matt also wanted a different teaching strategy: "I would rather have lectures by you" (the instructor). Matt failed to complete his reading reactions and preferred to "look at mostly my group's work" or "discuss verbally because talking is natural."

Julie also failed to complete her reading reactions and to engage at the community level. She considered others' work "very little." She also felt that "the different groups are working in stove pipes . . . besides the last few meetings there really is not valuable exchange of information . . . there should be more interaction across groups."

It appears our learners might have benefited from a more traditional approach first, followed by more gradual introduction of the constructivist strategies or additional scaffolding to support these strategies.

Carol, for instance, explicitly requested more feedback.

> I think this class was unique in its combination of individual and group tasks . . . this has a tendency to increase anxiety about grades, as things are beyond one's control . . . this was compounded by the low level of feedback received to the work posted.

And it is clear from Matt's comments that he would have preferred more direct instruction, "I would have rather had lectures" and "needed more instructional support."

Course Readings and Ownership in Learning

Brown and Campione (1990) wrote that understanding is more likely to occur when students are required to "explain, elaborate, or defend" their position to others. The participants in Altviews were asked to read theory-based articles in the field of alternate views of teaching and learning and to complete a series of questions for each of the readings. By answering these questions, participants contributed their own explanations to the articles and reacted to the ideas of others previously posted in response to the same articles. The assignment required learners to engage in a type of self-evaluation of their own personal position relative to that of others, to reevaluate their own position, and to elaborate the information in new ways. The reading reactions were designed to serve as a scaffold to promote knowledge building and higher-order thinking relative to the theory base supporting alternate views of teaching and learning. The substantive quality of the reading reactions showed evidence that new levels of understanding were reached by the participants in the Altviews class for those students who completed the reading reaction assignment.

Specifically, analysis of the reading reactions resulted in three categories (reflection, referencing, and higher-order thinking). The reflection category was further elaborated in terms of surface and deep reflections. A surface reflection was one that related a personal experience in the student's response to an article showing some level of relevancy in the reading. A deep reflection related the student's personal experience and included some restructuring of information based on personal feelings and beliefs. Refer back to Table 2 for the categories, codes, and definitions that emerged from the analysis An example of a deep reflection appears in this reaction to the Slavin (1991) article from one of the international students:

> In the Fall of 1993, I had the privilege of taking a research survey course which incorporated the use of the cooperative learning approach, which was new to me at that time. It was one of the most effective experiences in my life as a student. The cooperative learning process really impressed me, and I was convinced that I should use it as an art educator in the near future. I even asked myself why such an approach was not used in Kuwait? . . . Our ultimate aim was to get the job done together, and we did. I am still proud of that work, and still in touch with the members of my group. Cooperative learning is a method for improving the achievement of learning and other educational outcomes, and implementing such an approach should be a necessity in educational settings. This can be accomplished if we can succeed in creating a sense of commonality, and overcome the lack of communication among these groups.

The higher-order–thinking category included reading reactions that demonstrated knowledge synthesis and critical analysis of the articles. An example of a critical analysis to the Drucker (1994) article included the following response:

> My initial reaction to this article is that it is extremely biased towards business interests and rather cavalierly overlooks some tremendous social problems caused by the industrial revolution. It seeks to present that revolution as one that proceeded with a minimum of friction and upheavals without delving into the historical reasons behind such a revolution, i.e. the war machines and imperialist machinations it typically supported. The author also dismissed the violence of this century re: Hitler, Stalin, Mao as signifying nothing. This guy needs to go back to school and take some real history courses.

> The transformation of the social structure by the industrial revolution will be dwarfed by the transformation experienced by the information revolution. I would have to agree in some respects, but again, this author ignores the fact that this "information revolution" is just another form of imperialism—whoever holds the keys to the information is "the winner." He talks in terms of winning and losing—competitiveness may be everything in terms of business, but the idea of translating this to educational theory or ideas is really negative. What about sharing and cooperation?

Knowledge building is the creation of artifacts that capture the student perspective in the form of explanations, theories, and solutions (Bereiter, 1995). The quality of the reading reactions showed evidence of knowledge building for all of the participants in Altviews. That is, all students had instances of coding in at least one of the three categories with most participants' reactions falling into all three categories. The high quality of the reading reactions produced by individuals added new perspectives, explanations, and solutions to the accumulating

knowledge base showing evidence of the expertise of the community.

The reading reaction questions and identification of concepts or key ideas from the readings were intentionally designed as scaffolds for promoting higher-order thinking and, ultimately, knowledge building. The extent to which these scaffolds were effective directly contributed to the collaborative knowledge-building efforts of the community.

A strategy related to the course readings was also designed to promote ownership and self-direction in learning, and that was the opportunity for students to select the articles they wished to read throughout the semester. We hoped that students would be empowered to take personal responsibility and accountability for their own learning by selecting articles of interest and identifying associated key ideas, as well as assessing their own learning process through the confidential reports, fulfilling their group's role in accomplishing the collective goal, and participating in the democratic operation of the classroom environment. In her second confidential report, Mary expressed satisfaction with this aspect of the course. "I particularly enjoy the freedom and responsibility that allowing students to choose their own readings affords."

Article selection was based on tasks, negotiated in each learning group, associated with the group's role in developing the charter school. In addition to the readings, outside resources were added to the community database to assist with the overall effort of the community in accomplishing the collective goal. Group decision making was necessary in the selection and definition of the concepts and associated excerpts. This agreement was necessary to create the concept maps and select the readings to support the accomplishment of the collective goal.

Even though Altviews provided an infrastructure designed to enable students to take personal accountability and responsibility for their own learning, the provision of appropriate tools and resources to support students in knowledge-building activities does not assure that students will take advantage of the opportunity to learn. Those students functioned effectively in the Altviews environment who gained control of their learning process early in the semester, demonstrated a high level of value toward the community and their individual efforts, and had a high level of satisfaction from their experience in the course. Conversely, students who failed to work steadily throughout the semester, functioned primarily at an individual level, and did not see the relevance of course assignments, experienced a low quality of learning.

Lack of motivation leads to low levels of productivity (Keller, 1987). Keller has suggested that it is important to analyze the motivational levels of the audience and establish motivational strategies in order to measure the effect that motivation plays in the learning process. Too much stress or overload is destructive and does not stimulate growth, suggesting a need for balance between motivation and the feelings of overload. Perhaps an instrument could have been used that measured student motivational level toward the course goals and structure to identify those students who might need additional assistance. A simple survey administered at the beginning of the course asking each student to formulate personal course goals and to estimate how much time they expected to devote to the course might have been both revealing and useful.

Technology Tools

Leinhardt (1992) offered several core assumptions about teaching and learning that support a constructivist approach to designing collaborative knowledge-building environments. First, learning is an active process of constructing knowledge. Second, knowledge is a "cultural artifact"; we create it, share it, and transform the knowledge as individuals and groups. Third, knowledge that is distributed among group members or communities is an aggregate of knowledge that is greater than the knowledge of any individual within the community.

The overall effort of the Altviews community appeared to be supported by the Construe software. This tool was used to store information in the form of reading reactions, concept

definitions and excerpts, related Web sites, and other sources of outside information, all of which were used in the development of the charter school. However, as effective as Construe was for storing and integrating information, it may have been deficient as a tool to promote communication at a group and community level.

According to Warren, for example, the Construe system "should be the reinforcing mechanism" for class participation. He suggested that we add a chat room component to enable synchronous group discussion rather than asynchronous e-mail. Warren wanted immediate response to his issues, rather than having to wait for e-mail responses and then having to forward and resend to other group members. "It is very labor intensive to send e-mails, then re-send, forward, then re-forward just to discuss an idea. The more people that are added, the harder it becomes to circulate ideas."

Chris requested more traditional, face-to-face interaction. "Construe was an asynchronous and alone environment of ideas, information, and knowledge transfer that must be offset by the intimate, oral, and aural interchange between students . . ."

Other students had similar responses. Mary saw the effectiveness of the tool, but understood that the level of effectiveness was directly related to the quality of the input by all participants in the community. That is, the integrity of the output of a system is only as good as its input. Computer science has a term for this: *garbage in, garbage out* (GIGO). Because some of the students did not complete the reading reactions on time as Mary did, she believed the quality of her learning experience was somewhat diminished. "I am disappointed that not more students have been keeping up with their responses. I am somewhat angry with them for lessening the quality of my learning experience."

Most of the students thought that Construe strongly supported their learning efforts at an individual level, but was less effective at the group and community levels. This may be due to the lack of a vehicle for quick interchange of ideas and the need for all students to complete their reading reactions in a timely manner so that the information could be used by other participants.

Inspiration™ was the software tool used to develop the team concept maps. This diagramming tool allows the creation of nodes and links so that concepts can be spatially arranged and connected. The intent of this tool was to promote collaboration, discussion of multiple perspectives, and negotiation at the team level. There were no operational problems in using the software; however, the extent to which the tool was perceived to be useful varied among the participants. For example, Warren thought that concept mapping was "very effective in laying out core ideas." He stated that he could "get a sense and view of the key concepts and relationships to each other." Warren also thought that concept mapping was very effective in achieving the goals of the course and would use this strategy in the future.

Mary's view of the tool was somewhat different:

> Although I see this activity fits within the 2nd course purpose (generating connections among diverse concepts), I feel that I did not really get much out of the activity. Doing it at a group level was tedious at best. I would have preferred to work this out individually, or not at all.

There were several other comments similar to Mary's, all coming from participants in groups that experienced problems of one sort or another during the semester.

It appears, then, that the tools functioned well technologically in that students had no difficulty using them for individual and group assignments and, indeed, felt that their use of the tools enhanced the quality of their learning experience. Yet use of the tools did not achieve all we had hoped for. Certainly, the communicative functions of Construe bear improvement, but the issue probably goes beyond the tools themselves. That is, for a knowledge-building community to be truly effective, there seems to be a need for a feeling of connectedness. It takes a certain amount of time for the community to develop that feeling and come together in a collaborative fashion. The researcher noted several times in her journal that the students asked for more time for their final projects. Most felt that

another semester could have been beneficial in achieving the goals of the community. It takes time for teams to rise above a group level and to accomplish a shared vision of the community. The quality of the final reports indicated that collaborative knowledge building occurred at a group level; however collaboration at the community level was minimal and incidental rather than systematic. According to Senge, Kleiner, Roberts, Ross, and Smith (1994), this feeling of connectedness in learning organizations takes several years to accomplish in corporate settings. We may have needed more time in Altviews to develop a feeling of connectedness for the community as a whole.

Conclusion and Implications

It appears that how much learning takes place in a learning environment based on a community of learners approach depends to a great extent on the beliefs, expectations, and attitudes of the community members. Ingrained beliefs and an existing paradigm structure based on traditional instructional models cause tension and result in a continual struggle on the part of the student. The approach used in Altviews did not result in commitment from all students and failed to some extent at promoting collaborative knowledge-building discourse at the community level. Even though the class was strongly supported through a variety of scaffolds, and conducted in a democratic fashion, several of the students did not make the shift to self-directed learning. So, what can we learn from this study that may be useful to others interested in designing learning environments of this nature? Displayed in Table 3 are design guidelines that comprise the lessons learned from the current investigation, integrated with results of previous research.

Use scaffolds

Scaffolds can be used to promote higher-order learning and should be developed to promote explanations, elaborations, and self-evaluation around interrelated themes. The scaffolds used

Table 3 ☐ Design Guidelines for Collaborative Knowledge-Building Environments

Design Feature	*Guideline*
Use scaffolds	Use scaffolds at several levels to accommodate freedom and learning orientation; and that promote higher-order thinking and guide rather than drive the learning process to support students in self-regulated learning
Track the learning process	Use self-report techniques to measure the quality of the individual learning experience and use the information to guide intervention as appropriate
Balance tension	Promote productive discomfort leading to growth without overloading the student
Promote relevance and motivation	Analyze motivational levels and establish strategies to measure relevance and motivation relative to class activities by evaluating confidential reports and class discussion as well as using other instruments that might be useful for gathering this type of information
Promote a shared vision	Use instructional strategies and technological tools that promote a buy-in from the students, across group collaboration, and quick interchange of ideas at the group and community levels
Promote the acquisition of knowledge	Teacher and students identify key concepts or ideas in the content domain and use generative learning strategies and discourse to promote their acquisition

in the Altviews environment included reading reactions, concept identification, and concept mapping. Scaffolds should be developed at several levels to accommodate the freedom and learning orientation of the students in a self-directed learning environment. It appears as if the more freedom provided in self-directed learning environments, the more scaffolding required to support students not oriented toward self-regulated learning. However, this support should guide rather than drive the learning process.

Track the learning process

One approach to guiding rather than driving the learning process could be to closely track the quality of the student learning experience through self-report measures, and intervene when necessary. Tracking the learning process through self-report measures helps identify issues before they become problems that interfere with learning. Some of these issues can be anticipated and provided for in advance, and others occur during the implementation phase. A vehicle could be provided to identify and solve these issues.

Balance tension

The expectations, values, and beliefs that students bring into the learning environment directly affect the quality of their learning experience. Altviews used a nontraditional approach to teaching and learning that was new to the students. This shift from a teacher to a learning directed environment caused some level of discomfort that needs to be balanced with the workload. That is, students should not experience a level of discomfort that interferes with the quality of their learning. Perhaps an instrument that measures students' epistemology could help identify which students may need additional support to make the shift without the feeling of overload and discomfort that interferes with a quality learning experience. Too much stress and overload is destructive and does not stimulate learning. Also, other demands, affecting students outside the classroom, should be considered.

Analyze motivational levels

Relevance and motivational elements are critical to the learning process. Lack of motivation diminishes participation and ultimately learning. It is important to analyze the motivational level of the audience and establish motivational strategies to measure the effect motivation plays on learning. Self-report measures, such as confidential reports and instruments specifically designed to measure motivational levels relative to a particular approach to learning, could be used. Additionally, tasks and activities perceived as busy work negatively affect the collaborative discourse of the community. Community activities should have an apparent purpose in achieving the goals of the community and should be authentic relative to the content domain. A whole-class problem-solving activity holds promise to promote collaborative knowledge building if the activity serves as a shared vision rather than a collective goal.

Promote a shared vision

The shared vision of the community requires social support at the group and community levels. The instructional strategies and technological tools should promote collaboration across groups and group work space enabling the community to engage in quick interchanges of ideas and knowledge-building discourse. This discourse should provide feedback to the system from all the participants in the learning community, including students, teachers, and outside experts.

Promote the acquisition of knowledge

The acquisition of key concepts is critical in providing a strong foundation for a knowledge-building enterprise. Key concepts could be integrated into class activities supported by generative learning strategies and discourse to promote their acquisition. Key concepts are fact-based information that provides the foundation necessary to enable students to engage in higher-order thinking and promote knowledge-building discourse beyond the group to the community level.

CONCLUSION

The importance of tracking the learning process to guide intervention by the instructor, the need to balance tension by promoting productive discomfort leading to growth, and the promotion of a shared vision and tools that support community collaboration are all new ideas that emerged from this study. The use of scaffolds (Rosenshine & Meister, 1992), the promotion of motivation in learning environments (Keller, 1987), and the acquisition of knowledge to promote discourse (Scardamalia & Bereiter, 1994) have been examined previously and reaffirmed by this study.

Educators have recognized the need to cultivate higher-order thinking skills and alternate views of teaching and learning, even though they have disagreed about how to achieve these ends (Resnick, 1989). One potential solution is the design and implementation of collaborative knowledge-building communities that incorporate constructivist principles. A collaborative, knowledge-building approach offers an alternative model for both the design of classroom environments and distance courses. There is a new trend in education to use Internet-based tools, and to use distance education to reach more students over a larger geographical area; however, alternative models are needed to support this effort.

There is a growing body of knowledge about the contribution of constructivist principles to the design of collaborative learning environments based on a community-of-learners approach, and how emerging technologies can be used to support these ideas. This investigation represents a step toward providing empirically based guidelines to assist in the design and development of collaborative, knowledge-building communities. □

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REFERENCES

Bell, P., Davis, E.A., & Linn, M.C. (1995). The knowledge integration environment: Theory and design. In J.L. Schnase & E.L. Cunnius (Eds.), *Proceedings of CSCL '95: The first international conference on computer support for collaborative learning*. Hillsdale, NJ: Erlbaum.

Bell, P., & Winn, W. (2000). Distributed cognitions, by nature and by design. In D.H. Jonassen & S.M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 123–146). Mahweh, NJ: Lawrence Erlbaum.

Bereiter, C. (1995). Constructivism, socioculturalism, and Popper's world 3. *Educational Researcher, 23*(7), pp. 21–23.

Bereiter, C., & Scardamalia, M. (1996). Rethinking learning. In D. Olson & N. Torrance (Eds.), *Handbook of education and human development: New models of learning, teaching, and schooling*. Cambridge, MA: Basil Blackwell.

Bowen, B., Bereiter, C., & Scardamalia, M., (1992). Computer-supported Intentional Learning Environments. In F.Y. Phillips (Ed.) Thinkwork: *Working, learning, and managing in a computer interactive society*. Praeger: Westport, Conn.

Brown, A.L. (1994). The advancement of learning. *Educational Researcher, 23*(8), 4–12.

Brown, A.L., & Campione, J.C. (1990). Communities of learning and thinking, or a context by any other name. In D. Kuhn (Ed.), *Developmental Perspectives on Teaching and Learning Thinking Skills.* Contributions to human development, vol, 21, 108–126.

Derry, S.J., & LaJoie, S.P., (1993). A middle camp for (un)intelligent instructional computing: An introduction. In S.P. LaJoie and S.J. Derry (Eds.), *Computers as Cognitive Tools.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Drucker, P.F. (1994, November). The age of social transformation. *Atlantic Monthly, 274*(5).

Duffy, T.M., & Cunningham, D.J. (1996). Constructivism: Implications for the design and delivery of instruction. In D.H. Jonassen (Ed.), *Handbook of research for educational communications and technology*. New York: Macmillan.

Edelson, D.C., Pea, R.D., & Gomez, L. (1996). Constructivism in the collaboratory. In B.G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs, NJ: Educational Technology Publications.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C.M. Reigeluth (Ed.), *Instructional-design theories and models* (Vol. II). Mahwah, NJ: Erlbaum.

Jonassen, D.H. (1995). Supporting communities of learners with technology: A vision for integrating

technology with learning in schools. *Educational Technology, 35*(4) 60–63.

Jonassen, D.H. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional-design theories and models* (Vol. II). Mahwah, NJ: Lawrence Erlbaum Associates.

Kaufman, R., & Grise, P. (1995). *Auditing your educational strategic plan: Making good things better*. Thousand Oaks, CA. Corwin Press, Inc.

Keller, J.M. (1987). The systematic process of motivational design. *Performance and Instruction Quarterly, 26*(9), 1–8.

Lebow, D. (1995). *Constructivist values for instructional design: A case study of a graduate-level learning environment.* An unpublished doctoral dissertation, Florida State University, Tallahassee.

Lebow, D., & Wager, W. (1994). Authentic activity as a model for appropriate learning activity: Implications for emerging instructional technologies. *Canadian Journal of Educational Communication, 23*(3), 231–244.

Lebow, D., Wager, W., Marks, P., & Gilbert, N. (1996, June). *Construe: Software for collaborative learning over the World Wide Web.* Paper presented at the AECT/FSU Conference on Distance Learning, Tallahassee, FL.

Leinhardt, G. (1992). What research on learning tells us about teaching. *Educational Leadership, 4*, 20–25.

Miles, M.B., & Huberman, A.M. (1994). *An Expanded Sourcebook: Qualitative Data Analysis (second edition)*. Sage Publications. Thousand Oaks, CA.

Pea, R.D. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communications. *The Journal of the Learning Sciences, 3*(3), 285–299.

Perkins, D.N. (1991). Technology meets constructivism: Do they make a marriage? *Educational Technology, 31*(5), 18–23.

Resnick, L. B, (1989). Introduction. In L.B. Resnick (Ed.), *Knowing, learning and instruction.* (pp. 1–24). Hillsdale, NJ: Lawrence Erlbaum.

Rosenshine, B., & Meister, C., (1992). The use of scaffolds for teaching higher-level cognitive strategies. *Educational Leadership,* 4, 26–33.

Scardamalia, M., & Bereiter, C. (1992). An architecture for collaborative knowledge-building. In E. De Corte, M. Linn, H. Mandl, & L. Verschaffel (Eds.), *Computer-based learning environments and problem solving*. [NATO-ASI Series F: Computer and Systems Science] (pp. 41–46). Berlin: Springer-Verlag.

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

Scardamalia, M., & Bereiter, C. (1996). Adaptation and understanding: A case for new cultures of schooling. In S. Vosniadou, E. deCorte, R. Glaser, & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments*. Mahweh, NJ: Erlbaum.

Senge, P., Kleiner, A., Roberts, C., Ross, R.B., & Smith, B.J., (1994). *The Fifth Discipline Fieldbook: Strategies and Tools for Building Learning Organizations.* New York: Doubleday.

Slatin, J.M. (1992). Is there a class in this Text? Creating knowledge in the electronic classroom. In E. Barrett (Ed.), Sociomedia: Multimedia, hypemedia, and the social construction of knowledge. Cambridge, MA: MIT Press.

Slavin, R.E. (1991). Synthesis of research on cooperative learning. *Educational Leadership, 2*, 71–77.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* New York: Cambridge University Press.

Yin, R.W. (1989). *Case study research: Design and methods.* (rev. ed.). Newbury Park, CA: Sage.