CHAPTER

2

Coordination of Asynchronous and Synchronous Communication: Differences in Qualities of Knowledge Advancement Discourse Between Experts and Novices*

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INTRODUCTION

A challenge posed by Computer Support for Collaborative Learning is to stimulate the development of communities of learners. Computer-Supported Intentional Learning Environments (CSILE) as proposed by Scardamalia, Bereiter, and their colleagues is an educational philosophy for the design of computer-supported learning environments (Scardamalia & Bereiter, 1991, 1993, 1994, 1996; Scardamalia, Bereiter, Brett, Burtis, Calhoun, & Smith-Lea, 1992; Scardamalia, Bereiter, & Lamon, 1994; Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989). CSILE software (i.e., regular CSILE 1.5 and Knowledge Forum) is a communal database system in which learners are allowed to externalize their thoughts mainly in the form of texts and/or graphics

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called "notes" and then engage in collaboratively organizing their knowledge as objects to advance their communal understanding as a whole. This communal database structure has been found to provide learners with opportunities to be involved in knowledge advancement through distribution of their expertise (e.g., Oshima, Bereiter, & Scardamalia, 1995; Oshima, Scardamalia, & Bereiter, 1996) and to eventually facilitate learners' conceptual understanding of complex scientific phenomena in comparison with traditional instructions (e.g., Scardamalia et al., 1992). Thus, empirical studies so far have shown that CSILE is a powerful tool for transforming learning activities into knowledge building.

This study is aimed at exploring whether CSILE has generic effects to improve knowledge building discourse by extending the use of CSILE in a different culture. CSILE has been developed in Western culture and has been used in schools that have Western cultural values. Studies have shown that CSILE has positive effects on learning in the school system. The results may be limited by the cultural background. Students in Western classrooms have opportunities in the curriculum to express themselves and participate in discussion. In contrast, in Japan there is no established curriculum on discussion skills, although such skills are currently being considered as a potentially useful part of a student's education. Based on the differences in discussion skills between the two cultures, we may infer that CSILE would work in cultures where discussion or discourse is regarded as important. However, in cultures where the skills are not developed through educational practices, CSILE might fail in its goal of knowledge advancement. For investigating generic effects of CSILE on learning, we established a CSILE site in Japan to investigate the conditions necessary for its successful use. We first deployed the CSILE-based activity system in expert learners' activities to see how they would use CSILE and recognize it as a tool for knowledge advancement. Then, we went on to set up another CSILE site for novice learners based on results from the study of experts. Finally, through comparisons between the experts and the novices, we attempted to identify crucial factors for the successful use of CSILE and further scaffoldings for novice learners.

For describing and evaluating learners' activities supported by CSILE, we take the "design experiment approach" (e.g., Brown, 1992; Collins, 1990). As Brown (1992) argues, it is not strictly possible for educational researchers to control a variety of variables or factors in educational settings to determine the effects of the individual variables on educational outcomes. Educational practices are dynamic activities in which a variety of critical factors interact with one another. Because effects on educational outcomes come from such interactions among the variables, what we have to consider are not changes in individual variables but interactive relationships among the variables and their consequences. Therefore, strict manipulation of variables in such dynamic activities may often disturb appropriate interactions among the variables; consequently, the outcomes are not necessarily what we would like to investigate. This study, in particular, investigates three different communities in different contexts supported by CSILE. The use of CSILE and its effects totally depended on how CSILE was utilized within the users' schedule or intentions. We are, therefore, concerned with how to improve each practice by designing activities supported by CSILE rather than with the individual factors that affect specific performance measures.

Because we are concerned with the design of learning environments, traditional experimental design and its analysis techniques are inappropriate for our research purpose. For describing dynamic functions of learning, we base our analysis on Activity Theory by Engeström (1987, 1993, 1996). Engeström's framework of human activity consists of six sociocultural components of human activities and gives us some perspectives on how learners as a community engage in their activities supported by various tools. We attempt to evaluate CSILE deployment in three communities by analyzing how learners' recognitions on learning or their activities change through the deployment of CSILE by content analysis of their discourse in CSILE, participatory observation, interviews with learners, and questionnaires.

In this study, we have two research questions. The first is how the asynchronous communication by CSILE with or without face-to-face communication changes learners' activity systems and which format of curriculum is better in facilitating knowledge advancement. Information technologies (ITs) such as CSILE are based on a computer network and would be expected to be used for distance learning. A key component in distance learning is the set of tools for asynchronous communication on the computer network. It is useful for us to discuss whether the asynchronous distance communication can be a substitute for the current synchronous communication in learning activities, and if not, then how asynchronous communication tools could be incorporated into synchronous learning activities for creating more effective distance learning curriculum. Asynchronous communication tools are considered important in conducting intentional learning in the classroom as well (Bereiter & Scardamalia, 1989). Educational practice would become more learner-centered and project-based in the future. Asynchronous communication tools such as CSILE are expected to play crucial roles in conducting such practices by providing support for learners to collaborate beyond physical and temporary limitations in the classroom.

Our second research question involves comparing expert and novice learners in their approach to engaging in more productive discourse on the computer network. For expert learners, CSILE philosophy would be much easier to accept because the expert learners are engaged in knowledge building activities. However, for novice learners, the philosophy is difficult to accept because it is different from the philosophy they have developed through their schooling (Scardamalia & Bereiter, 1994). Even if they can accept the philosophy itself, the novices need to develop strategic knowledge and skills for managing their knowledge building with CSILE. We attempted to identify what strategic knowledge novices need for their knowledge advancement supported by CSILE.

In Study 1, we focus on expert learners. Two graduate school programs are targeted as communities supported by CSILE. In Community A, graduate students use CSILE as a new communication channel in addition to their normal channel (i.e., face-to-face communication). In Community B, graduate students take a course through CSILE only.

A variety of analyses were conducted with participatory observation data, interviews with the students, and contents reported in the database. We found through our observation and interview data that: (1) students in Community A efficiently used CSILE because they had recognized problems with their synchronous communication, (2) students in both communities reported CSILE as a powerful tool for improving their knowledge advancement through self-monitoring and asynchronous collaboration, which they thought had not been possible before using CSILE, and (3) students in Community A intentionally changed the roles of their face-to-face communication so that their CSILE communication could be incorporated into their activity.

With respect to what discourse the two communities engaged in, it was found that Community A produced better inscriptions of their arguments than did Community B. One of the remarkable factors for the better inscription was that discourse on the network by Community A was constructed through coordination of learning in face-to-face discourse.

From the above results, we concluded: (1) that expert learners were able to utilize CSILE for improving their knowledge building activities and (2) that necessary factors for the successful use of CSILE would be users' recognition of necessity of such technologies for resolving their communication problems and effort to coordinate the different communication channels (i.e., synchronous and asynchronous ones).

Based on the results in Study 1, we designed learning activities for novices that combined face-to-face and asynchronous communications in Study 2. Sophomores in an undergraduate course on cognitive science used CSILE as part of their regular curriculum. The students were given four lectures, in between which they had a few weeks for discussing the themes through CSILE communication. Data were collected through questionnaires, participatory observations, and contents reported by the students.

Results based on questionnaires and observations showed that: (1) students who had frequently used CSILE recognized the effects of CSILE on their learning, (2) students who effectively used CSILE had learning goals in the course, and (3) some students in transition from task-oriented to learning goal-oriented had difficulties in reporting their thoughts as notes and managing their learning schedules.

Novices were found to start their collaborative discourse by repeating questioning–answering and then gradually establishing simple structures of arguments as inscriptions such as reference–claim–qualification. These results suggested that (1) a missing skill in novice learners was the ability to work in a culture of learning while inscribing their thoughts as arguments (i.e., they did not have social rules of inscription development through collaboration) and (2) their discourse was mostly devoted to knowledge telling activities (Bereiter & Scardamalia, 1987) and hence they missed the metadiscourse that controls activities of constructing inscriptions.

METHODOLOGICAL ISSUES

Descriptions of Global Views of Educational Settings Targeted in This Study

We use the Activity Theory approach to our design experiments. Figure 2.1 shows Engeström's (1987) triangular model of human activity. Engeström extends a simple triangular structure of tool-mediated activity (Leontiev, 1981) by placing it in a more culturally based structure of activity. In his framework, a human activity mediated by tools is not viewed as independent of other activities but is totally dependent on the activities that are simultaneously being conducted by the members of the community in a

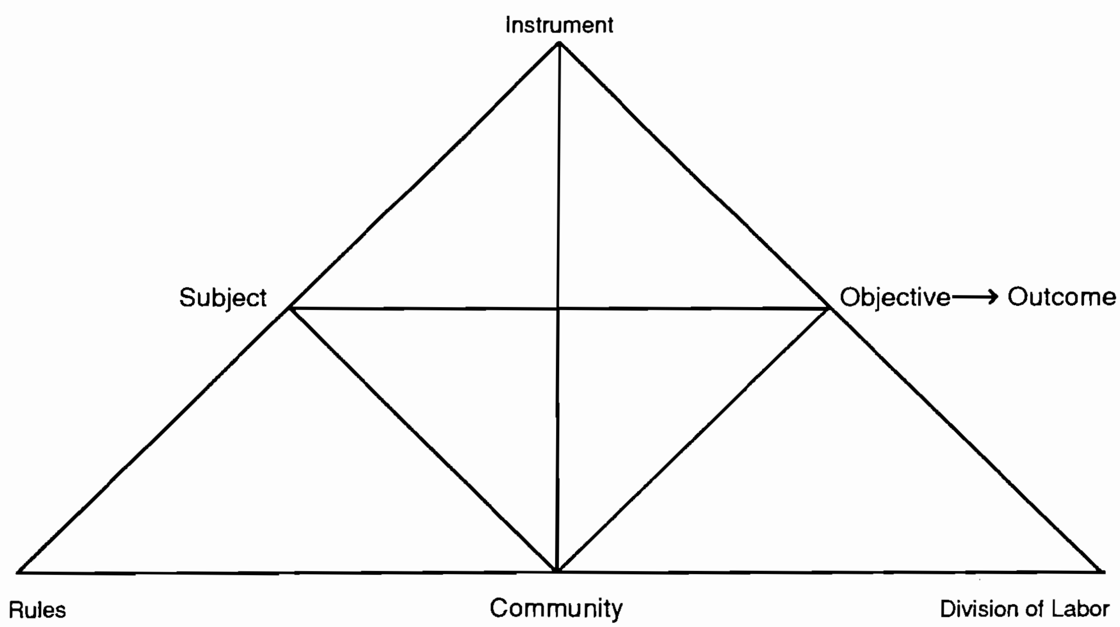


FIG. 2.1. The general framework of the human activity system by Engeström (1987).

more global structure of activity. The framework suggests that every human activity (the relationship among subject, instrument, and object) should be described from the perspectives of: (1) how the human is conducting the activity as a member of a cultural community (i.e., the relationship among subject, community, and rule) and (2) how his/her activity contributes to the accomplishment of the more global activity in the community (the relationship among subject, community, and division of labor). Thus, in applying this triangular model to learning settings, how learners engage in their activities can be described from the perspectives of: (1) how they are working as members of the learning community and (2) how their activities are organized in constructing the learning activity.

From the point of view of learners' activity in CSILE, the following hypothetical framework of activity could be articulated. In CSILE, because every learner is engaged in collaboration through computer communication as well as face-to-face communication, we can constitute as many activity systems as there are learners in a setting. All participants including the target participants can be put in the component of "community" as a team of inquiry. Furthermore, the following constitute the component of "instrument" in the framework: As a typical semiotic tool for thinking, written discourse as well as oral discourse works as a tool for learning. The database allows participants not only to represent their thoughts and knowledge but also to manipulate them in the represented form. It enables participants to organize knowledge and to asynchronously collaborate with others.

Analysis of Discourse as Knowledge Advancement by Using Toulmin's Argument Framework

This study focuses on the structure of discourse in the asynchronous communication as well. In academic disciplines, written discourse, particularly journal publishing, plays a crucial role in knowledge advancement (Bereiter & Scardamalia, 1993). Scientific arguments in written discourse have a specific structure (Eichinger, Anderson, Palincsar, & David, 1991; Toulmin, 1958). Any *claims* in the discourse should be based on *data* (or *references*), *warrants*, and *backups*. Further, the claims should be articulated through *qualification* and *rebuttals*. Scientific discourse is progressive in the sense that scientists are attempting to challenge others' and their own claims to construct higher levels of understandings as social agreements in the communities (Bereiter, 1994). They are engaged in reflective and metacognitive activities to attain such high qualities of scientific knowledge. Thus, knowledge represented in written discourse is structured based on the specific frameworks of arguments and elaborated with metacognitive rules. In this study, we attempt to describe how experts (represented by graduate students) and novices (represented by undergraduates) structured their arguments in psychology and cognitive science courses and then collaboratively articulated their arguments through asynchronous communication.

STUDY 1: DEPLOYMENT OF WEBCSILE WITH OR WITHOUT FACE-TO-FACE COMMUNICATION IN GRADUATE PROGRAMS

Study 1 was aimed at exploring how CSILE would be integrated into our current university courses, particularly at the graduate level. We had the following reasons for implementing CSILE in graduate schools. First, we had some requests from faculty to implement CSILE in their classes. Particular reasons in each class will be described later. Second, we thought it worthwhile to deploy CSILE in a graduate program as a means of exploring how expert learners make use of the new communication tool for improving their activities. Two graduate courses at two different universities were targeted in this study.

Community A

Subjects and Community. This community consisted of 19 graduate students (master and doctoral) and a postdoctoral fellow in a psychology course titled "Human-Environmental Psychology." The instructor had been an associate professor at his university for five years. The students were from a variety of subdisciplines in psychology such as psychiatry, cognitive psychology, educational psychology, and environmental psychology. The course continued through the first semester.

Objectives. The shared objective for them to pursue in the course was to understand recent ideas on "tool-mediated human activities" and "affordance" and then to consider designs of "human friendly" environments.

Instruments. For the purpose of the course, the participants decided to read three books related to their theme. The course took place once a week in a face-to-face classroom. During the two weeks prior to implementing WebCSILE, students had been writing their thoughts on index cards and then submitting the cards to the instructor on a weekly basis. The instructor had organized the cards and made copies to distribute as a means of allowing students to share their thoughts with others in the class. Then, instead of the cards, they began to use WebCSILE for additional discussion following their face-to-face discussion. Although all participants did not have unlimited Internet access, they could use computers at their laboratories when they wanted to access CSILE.

Rules and Division of Labor. The community had a traditional learning style in graduate courses at Japanese universities. Some portion of the reading assignments was assigned to students every week. The responsible students prepared brief summaries for their discussion and then presented their initial arguments. Thus, there was an obligation for each member of the seminar to prepare their assigned portion of the reading assignments and this led to a rigid division of labor, which usually did not change over time.

One of the reasons that the instructor in the course wanted to use CSILE was the challenge he faced in changing students' rules in the class. Through our participatory observation and informal talks with students, we had recognized that knowledge-building activities in the community had not been sufficiently collaborative. Students did not frequently ask questions and did not comment on other participants. One crucial factor leading to this phenomenon might be the discussion style in Japanese culture. However, another factor, we thought, might be the physical and temporary limitations of face-to-face communication. In our informal talks with the students, they reported difficulties in coordinating a variety of ideas on reading assignments and then articulating their own ideas in face-to-face discussions although they recognized that collaborative activities were important to advance their knowledge. Furthermore, in our attempt to have them talk in small group settings in a face-to-face context, they could efficiently manage their collaborative works. We thought that CSILE would provide this community with another layer of communication, which is asynchronous, so that they could go beyond the limitations of face-to-face communication.

Community B

Subjects and Community. This community consisted of five M.A. students and an instructor. The instructor had been a faculty member at the university for one and a half years. The students were from different disciplines in the school of education.

Objectives. This course took place as summer sessions from July through September in 1997. In the first class, the instructor introduced the aim of the course and the reading assignment, a book on computing in education written by a professor well known in the area. The students were required to read the book and then discuss ideas in it to consider and design educational environments supported by information technologies.

Instruments. As an attempt of our design experiment approach, we decided to manage this course only online through the World Wide Web (WWW). The existence of face-to-face communication has been one of the factors frequently discussed in CSCW (Computer Supported Cooperative Work) literature. Some studies showed that an e-mail conference system dramatically reduced discussion time dominated by particular individuals and facilitated more productive discourse (e.g., Dubrovsky, Kiesler, & Sethna, 1991). Other studies focused on unique characteristics of asynchronous communication in comparison with face-to-face communication (e.g., Finholt, Sproull, & Kiesler, 1990; Kraut, Galegher, Fish, & Chalfonte, 1992). They suggested that the two types of communication (synchronous and asynchronous) play different roles in conducting complex cognitive tasks and that coordination of the two is crucial. Through our design experiment, we were concerned with what roles the two types of communication played in knowledge building activities and how learners recognized the types of communication in their activities.

Besides the reason that this was part of our design experiment, we had other reasons to manage the class in this manner. First, we had difficulties in managing regular face-to-face meetings in the summer sessions. The participants, including the instructor, had tight schedules in the summer. Second, the network communication was new to most of the students. The instructor thought that this was a good opportunity for the students to involve themselves in such a communication style to discuss their theme (i.e., educational environment supported by information technologies).

Rules and Division of Labor. One rule applied by the instructor in this course was that the instructor regularly summarized portions of the book so that the students could see what to discuss. Then, the students built their thoughts on the instructor's summaries. In addition to this, they were allowed to start their own discussion if they wanted to do so. The division of labor in this course was somewhat similar to that in Community A. The students were required to read all the materials assigned by the instructor; their main task was then to report their thoughts in the database.

WebCSILE as an Asynchronous Discourse Engine

We set up a World Wide Web server for WebCSILE at the authors' university site. WebCSILE is a WWW version of CSILE 1.5. The network architecture is shown in Fig. 2.2. Although functionalities in WebCSILE were limited in comparison with those of the regular CSILE 1.5, it could be used more widely across different sites with clients across Windows and Macintosh platforms. Since most of the participants in this study had Windows machines and had to access CSILE through the Internet, we decided to use WebCSILE rather than the regular CSILE 1.5. Another reason for the use of WebCSILE was that it was compatible with the Japanese operating system.

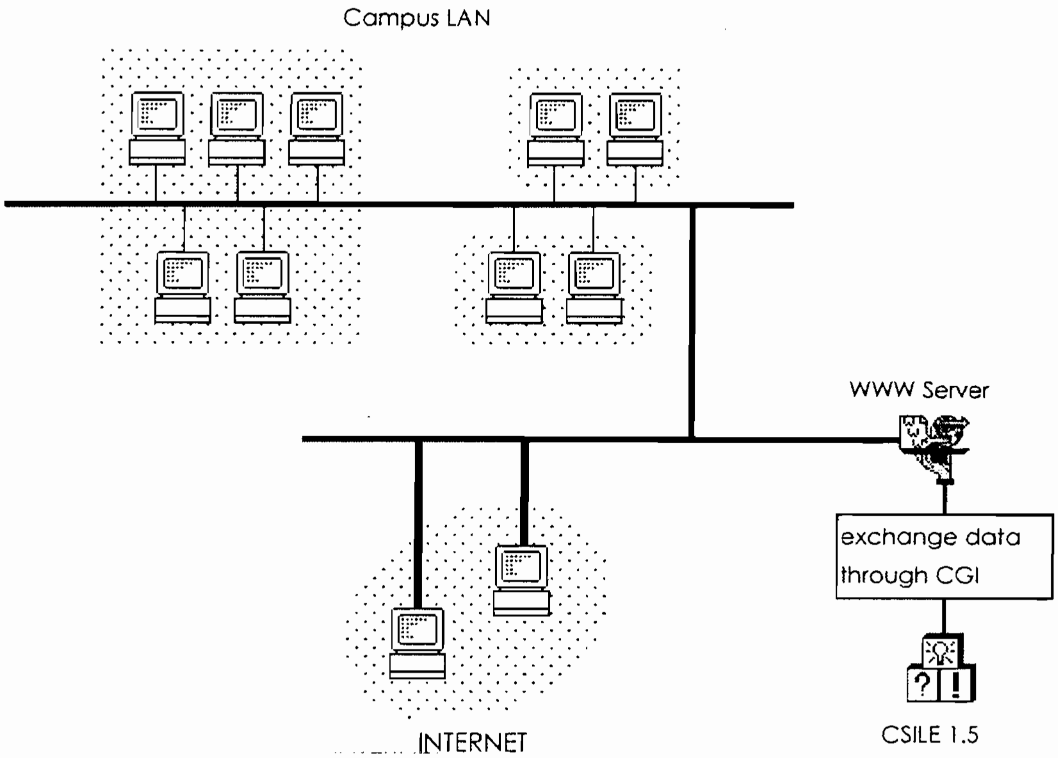


FIG. 2.2. Network architecture for WebCSILE.

Participants in this study could access WebCSILE through the WWW if they had Internet access. Figure 2.3 shows the first page on the Web. The participants were required to type in their username and password and then click on the "Sign On" button. Next, they were given a topic page shown in Fig. 2.4. There were topics for four different communities, as they shared one database. The participants in each community had to choose one topic to contribute to their community. Finally, they could see the title window in which related notes were structured in threads as default. They could change the view among "thread," "author," and "date" options. The "author" view was a list of notes sorted by authors, and the "date" view was a list sorted by dates beginning with the most recent note. Thus, each view provided the participants with different information on the database.

After signing on, the participants could report their thoughts at any window. The left side of the window showed possible options. Participants could type in their thoughts as new notes or comments on others' thoughts. In the text area, they could use Hypertext Markup Language (HTML). If the participants were familiar with HTML, they could visually elaborate their notes. Furthermore, they could put their graphical information in their personal directories so that they could link the graphics in their HTML area of their notes. In addition to its multimedia nature of notes, WebCSILE had another functionality to support participants moving between notes. Figure 2.5 is an example of a WebCSILE note. This WebCSILE note had two different

FIG. 2.3. The window of WebCSILE top page through Netscape.

hyperlinks automatically created by CGI scripts. One type of link was "references." This was a metaphor from journal papers. Participants could jump to the target note on which the note commented. The other type of link was unique in the hypertext structure of the WWW, "notes that refer to this note." This link took participants to notes that referred to the original note. Thus, in WebCSILE, learners' manipulation of asynchronous discourse was supported by its hypertext nature as well as its database functionalities.

CSILE Use With or Without Face-to-Face Communication

Activity Systems in the Two Communities

Here, we describe how each community changed its recognition of learning activities through use of WebCSILE. Based on the Activity Theory

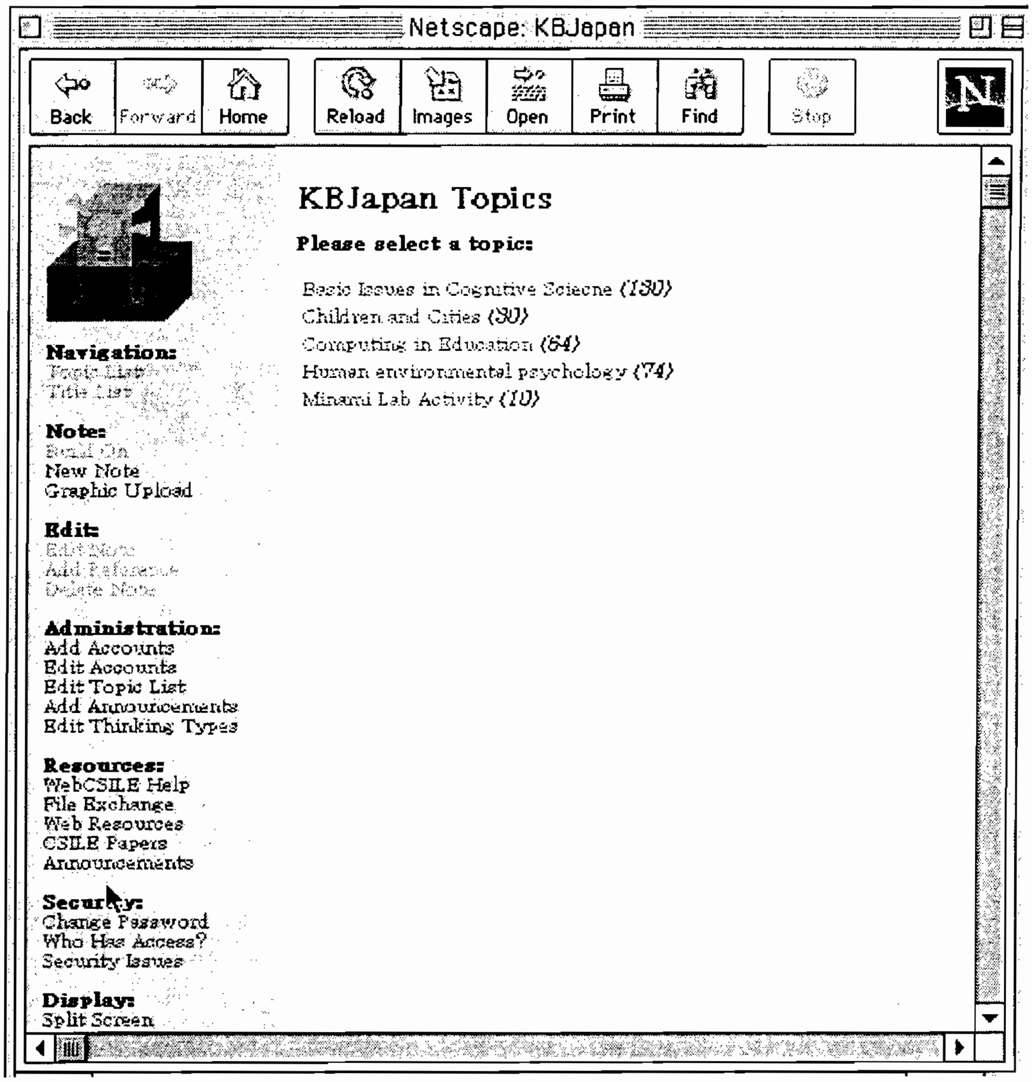


FIG. 2.4. The window of a topic page of WebCSILE through Netscape.

framework (e.g., Bødker, 1996; Engeström, 1993, 1996), we particularly focused our analysis on how rules in their communities were changed, how their division of labor was changed, and how WebCSILE was deployed within their ongoing activities.

Community A. Eight students were regularly involved in written discourse on WebCSILE. Through our participatory observation in the course, the students were found to be "knowledge building goal-oriented" (Ng & Bereiter, 1991). Although the course theme was not directly related to their research topics, they all were interested in constructing further arguments based on the theoretical ideas discussed in the course.

The knowledge building goal-oriented group had been concerned with learning situations. Their main problem in the lab, some of them reported,

FIG. 2.5. The window of a student's note in WebCSILE through Netscape.

was that they could not efficiently manage ideas through their face-to-face communication. When some good thoughts appeared, they were frequently lost because no one thought to write them down. They needed some collaborative notebooks so that anybody could trace the previous discourse at any time. Another problem they had was that the pattern of turn taking in their face-to-face communication had been mostly centered around the instructor. There had not been many exchanges among students. Division of labor in their face-to-face communication had been distributed between the instructor and the students but not among the students.

Through the deployment of WebCSILE, the knowledge building goal-oriented group engaged in collaborative discourse, which had not been seen in their face-to-face communication. Our interviews revealed that participants in the goal-oriented group recognized WebCSILE as a useful tool for their knowledge advancement. In particular, they valued the following features: (1) the capability for reflecting on their thoughts in written discourse at different times and (2) the fact that they could individually grasp what had been concluded as a group or community.

Knowledge advancement through the use of WebCSILE might stem from a couple of reasons. First, members of the knowledge building goal-oriented group had already recognized their problems in managing their thoughts in the synchronous communication and had been looking for technologies that could support them. Second, the asynchronous communication worked as a channel for the students to exchange their thoughts. The instructor did not often report his thoughts. This fact led the students to communicate more frequently with one another, without the instructor.

Community B. These participants were interested in the design of learning environments supported by computers. Their shared objective was to build their knowledge on learning environments through their collaborative discourse in WebCSILE. Thus, they shared a knowledge building goal.

Because the participants were from a variety of programs at the graduate school of education and most of them had not seen each other before the course, we could not describe rules or division of labor of their activity system before starting the course. Further, they only engaged in the written discourse, without face-to-face communication. Therefore, based on our interviews with them, we describe how they came to realize rules and division of labor through their written discourse communication.

First, the participants recognized the importance and the effectiveness of asynchronous communication. They reported that they could grasp a whole picture of discourse by running through the title view or reading note by note at their convenience. Second, they also reported that they had felt a lack of intensive communication. Although their written discourse could be arranged in the three different views in the database so that the students could reflect on their thoughts in some contexts, they could not be sure how each participant recognized the discourse going on in the database. This "meta" level of discourse is crucial for organizing thoughts, and some studies conclude that such a metadiscourse is usually mediated through oral discourse (e.g., Perkins, 1993). Thus, the solo use of written discourse in the asynchronous communication may not be the best approach to knowledge advancement. Coordination of the two types of discourse should be crucial to sustaining productive discourse.

Discourse Seen in WebCSILE

For describing how progressive discourse in WebCSILE proceeded in each community, we took the case study approach. We chose one example of discourse in each community evaluated as best by two university professors; we then attempted to describe each discourse through the argument framework by Toulmin (1958).

Toulmin's framework of the argument has been applied to collaborative learning research to describe what's going on in students' discourse, or to discern how similar to or far from scientific discourse their discourse is. Eichinger et al. (1991), for instance, investigated how elementary school students managed their ideas through their collaboration in problem solving and then how their discourse appeared based on the argument framework by Toulmin. The results showed that patterns of discourse were critically different from those employed by scientists. Elementary school students attempted to defend their own claims and attack those of others. Scientists, however, did not have clear claims in the initial stage of their discourse. Rather they attempted to qualify their tasks from a variety of points of view and collaboratively considered warrants and backups for each possible claim. Thus, discourse by the experts was found to be socially constructed through distributed expertise, and this aspect was found to be crucial to scientific discourse.

Although the argument framework by Toulmin was a useful tool for us to describe how written discourse was progressing in WebCSILE, we had some difficulties in applying the framework to our data. First, our data were written discourse in university courses and the tasks were ill-structured, unlike the carefully structured task in the Eichinger et al. (1991) study. The students were asked to solve this problem after learning appropriate scientific knowledge on the matter. The task for our participants was to collaboratively advance their knowledge reading assignments. Because of the nature of the task, it was difficult for us to identify alternatives of possible claims. The range of possible claims was very broad and the problem spaces in which the participants were engaged were in a continuous state of flux. For these reasons, we considered the participants' discourse to be based upon the reading assignments and other available resources. Three social scientists (one faculty and two graduate students) read the reading assignments in each community and then evaluated discourse in WebCSILE based on its relevance to the reading assignments.

Second, because the task in which the participants in this study were engaged was not to choose which one of several alternative claims were a correct answer but to create claims, streams of their discourses were multidimensional. Therefore, we described how new claims were related to previous discourse.

Third, since arguments in the discourse were socially constructed through collaboration, the participants sometimes requested others to describe specific components of the argument framework, such as claims ("What do you think of this?"), qualifications ("Is anyone an expert on this?"), and backups ("Does anybody have data or evidence?"). We added these requests as new components of the argument framework to analyze the written discourse.

Discourse in Community A. Appendix A shows the argument framework in a progressive discourse seen in a thread by Community A. This thread consisted of nine notes by six participants created over a period of more than a month. The target argument in reading assignments was focused on concepts of "invariants" and "direct perception" in the affordance theory (e.g., Gibson, 1979). In the first three notes, three different students started three different streams of discourse through their rebuttals, qualifications, and claims. Although the three referred to different aspects of the original argument or discourse in face-to-face context (these are represented as "Ref_1," "Ref_2," and "Ref_3" in Appendix A), students who followed the discourse attempted to construct their understanding through articulation of the three perspectives on the same phenomena (they referred to the instructor's simple demonstration in class).

Discourse in Community B. Appendix B shows the argument framework in the discourse seen in a thread by Community B. This thread consisted of 13 notes created by all the participants in the course during a period of 28 days. The target argument was written on the topic of learner-centered design of learning environments. Besides the characteristics stated in Community A, this discourse had a unique feature. The participants expanded their problem space by approaching the problem from many perspectives rather than by focusing on a few specific aspects with claims and rebuttals. Although the participants actively engaged in their discourse, this discourse was not evaluated by the professors as crucial knowledge advancement.

From our perspective that discourse should be convergent to reach social agreements of participants' understanding, the framework of discourse by Community A might be more ideal than that by Community B. Participants in Community A were more focused on a specific aspect of their reading assignments or face-to-face discourse as their target references. They then approached the discourse from multiple perspectives such as by creating some hypothesis or model and then searching for evidence to support or reject their perspective. Two remarkable characteristics seen in the discourse by Community A in comparison with discourse by Community B were that (1) participants carefully summarized their previous discourse in their face-to-face context (e.g., "what we have reached so far in our class talk was, I guess, . . . "), and then attempted to follow the direction of their face-to-face discourse, and (2) through our interviews with the participants and participatory observation on their face-to-face discourse, we learned that the participants spent time in their face-to-face discourse preparing for discussion in WebCSILE rather than reaching any social agreements.

We found in Study 1 that expert learners tended to coordinate their different communication channels for the purpose of advancing their knowledge. WebCSILE was welcomed as a powerful tool for them to organize different perspectives on their face-to-face discourse. This finding was also supported by the data from Community B, members of which did not engage in face-to-face communication in the course. The students in Community B reported the importance of their face-to-face communication to make their asynchronous communication more progressive or productive. Thus, graduate students as expert learners succeeded in adapting themselves in the IT-supported learning environment through their efforts to collaboratively coordinate their communication channels. Most important is that qualities of their face-to-face communication were changed with the deployment of the new asynchronous communication. The participants missed their meta-layer of discourse, which is very important in intensive decision making.

In summary, results of Study 1 demonstrated the following: First, WebCSILE was useful for expert learners to advance their knowledge in the context of graduate courses. They successfully coordinated the new communication channel with their original activities by changing the roles of their face-to-face discourse to prepare them for the written discourse. Second, as reported by some participants, frequent externalization of their thoughts was quite new even to graduate students. This activity was found to facilitate self-reflection on their previous ideas and collaboration to reach shared understanding through coordination of their various perspectives.

STUDY 2: IMPLEMENTATION OF WebCSILE IN AN UNDERGRADUATE COURSE

In Study 2, we extended target communities to novice learners. We had two study purposes. First, we were concerned with how novice learners made use of CSILE in their course work. Second, we were interested in how novice learners learned in the context where synchronous and asynchronous communication were coordinated by the course instructor. Although this study was not conducted to make direct comparison with the results in Study 1, we thought that we could explore some crucial factors for the successful use of WebCSILE for the improvement of discourse by novice learners.

Community C

Subjects and Community. This community consisted of 30 undergraduate students (sophomores) in a course with an instructor. All students were from the department of computing in education.

Objectives. The main aim of the course was to learn basics in cognitive science, which is particularly related to educational research. The students were required to take part in the instructor's seminar and discuss the topics on WebCSILE.

Instruments. It was difficult for the instructor to have all students actively participate in discussion face-to-face because of the class size. Unlike the instructor's expectation, face-to-face communication in his previous courses had been the traditional "knowledge-transmission" model of learning. Written discourse on the computer network, however, was expected to produce opportunities for the students to communicate in a more flexible way. Students were required to report their thoughts in WebCSILE and then articulate their thoughts for the purpose of being prepared for their final reports. With regard to access to the Internet, they all had their own laptop computers with Local Access Network (LAN) cards so that they could access the network at any time in designated places within their campus.

Rules and Division of Labor. As is usually seen in any class at Japanese universities, undergraduates had a culture based on a "knowledge-transmission" model of learning. The students reported, in a survey conducted during the course, that they perceived themselves as recipients of knowledge from the instructor. They had not yet created a culture of collaboration to attain mutual understanding in the class. Their main activities in courses they had taken before had been organized as individual tasks.

To give students the opportunity to intentionally engage in knowledge building through collaborative articulation of their thoughts, the instructor decided to use WebCSILE as a discourse engine in the course. This course took place in the second semester consisting of 15 weeks. The instructor had four face-to-face meetings in which he presented educational studies in cognitive science and asked the students to report their thoughts in the database between the meetings (usually two or three weeks apart).

What Happened in the Community of Novice Learners

In this section, we first describe the participants' performances in WebCSILE to clarify how they used WebCSILE as a tool for their knowledge advancement. We next describe their activity systems through use of the technology in their activities.

Statistical Indices of WebCSILE Use

Table 2.1 shows frequencies of reported notes in isolation and threads.[1] In Communities A and B, numbers of single notes were almost equal to numbers of thread notes. In contrast, in Community C, the number of thread notes

[1]We define threads here as sequences of commentaries that do not include the first notes if the notes were for summarizing the contents as anchors.

TABLE 2.1
Note Frequencies*

	Thread Notes	*Single Notes*
Community A	34	19
Community B	25	24
Community C	106	59

*Thread notes versus single notes.

was almost twice the number of single notes. Thus, undergraduate students in Community C were more engaged in turn taking in the written discourse.

An advantage of asynchronous communication is that a stream of talk or turn taking does not have to be temporarily constrained. Figure 2.6 shows such an advantage of the written discourse in the asynchronous communication. The figure is an example of a title view sorted by thread. Each line manifests a note with its title, note number (in order to be reported), and author's name. First, the stream of turn taking is multidimensional. Starting with the first note #140, three comments followed the note (#143, #149, and #156). Further, in the third stream through note #156, two comments followed. Second, asynchronous commenting in each stream should be addressed as well. As we can see in the note numbers, these notes in each stream were not reported continuously. (If the notes were reported continuously, the numbers would be continuous.) Thus, asynchronous communication tools can provide participants with a new communication channel by which they could control multiple threads of discourses.

For the analysis of asynchronous turn taking, we assigned a value of how each note was asynchronously reported using the following calculation:

$$\text{asynchronicity value} = (\text{note number assigned to each comment}) - (\text{note number assigned to the target note}) - 1.$$ [2]

Then, a one-way analysis of variance (ANOVA) on mean values of thread notes among the three communities was conducted. The results showed that a mean value in Community C was significantly higher than those in Community A and B, $F(2, 112) = 5.40$, $p < .05$, (Fig. 2.7).[3]

[2]The first notes in threads were not considered as comments.

[3]The analysis was affected by the size of the communities. The more learners that were engaged in asynchronous discourse, the higher the asynchronicity values. One possible way of reducing the effect of community size may be to reduce the asynchronicity value of each thread note by average numbers of single notes. This is based on the assumption that single notes were written at equal pace between thread notes. On the basis of the data we had in this study, this reduction of the asynchronicity value would make the original differences more remarkable.

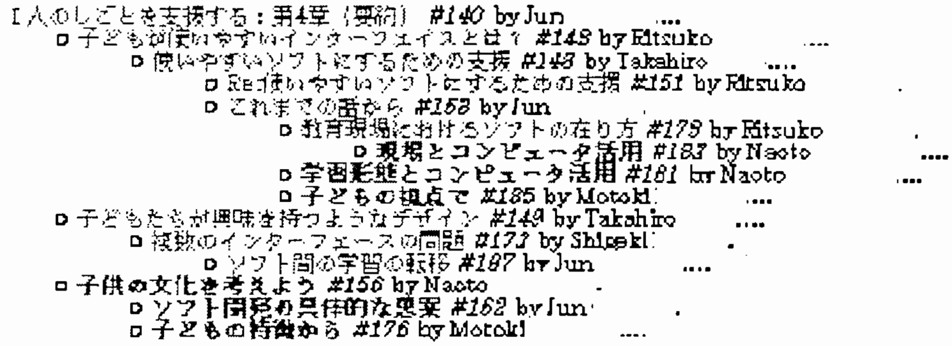


FIG. 2.6. An example of turn taking in a thread.

Activity System in Community C

Community C consisted of 30 undergraduate students who were majoring in computing in education. Because they usually met in the class but did not talk about the contents in the whole group, patterns of their face-to-face communication were analyzed based on our sociometrics questionnaire conducted during the course. Comparison of the synchronous and the asynchronous communications showed that the students engaged in totally different communication patterns through the two channels. In the asynchronous communication through WebCSILE, the participants were commenting on thoughts by others with whom they did not frequently communicate face-to-face.

As learning went on, the students developed three types of goals. One group, which adopted a "learning goal-oriented" (Ng & Bereiter, 1991) approach, was frequently engaged in written discourse to understand the contents of the course. In the questionnaire conducted in the class, they reported their recognition on the importance of the asynchronous communication tool, monitoring their own learning, and problems of their learning activities to effectively use the technology. There was a transitional group that was engaged in the written discourse in some threads. In the questionnaire, the transitional group reported difficulties in using the technology to make their learning more productive and to reflect on their own learning. The final group consisted of participants who rarely participated in the written discourse. In the questionnaire, participants in this final group reported how problematic it was for them to access the homepage for the course, but they did not report any reflections on their own learning.

In Community C, the learning goal-oriented and the transitional groups made use of WebCSILE as a tool for knowledge advancement. Through the new asynchronous communication channel they succeeded in expanding their learning community. They came to recognize that learning through

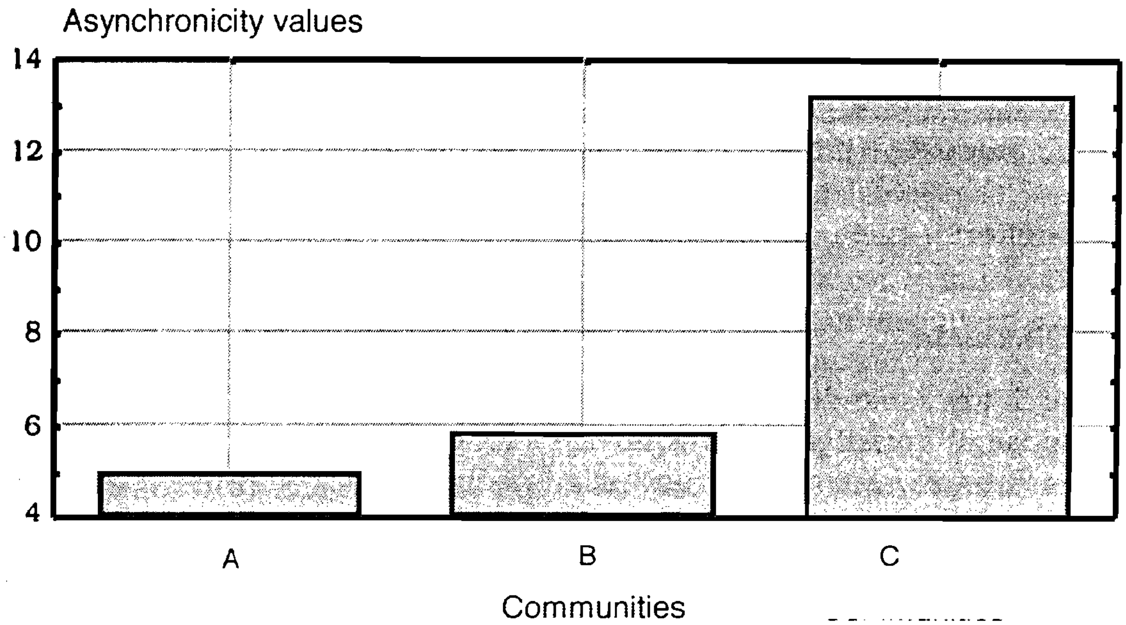


FIG. 2.7. Mean scores of asynchronous turn takings seen in the three communities.

collaboration with others was crucial to knowledge advancement. However, the third "task goal-oriented group" was not aware of learning as knowledge construction. They did not think that communication with others led them to further advancement of knowledge.

Discourse in Community C

From results in Study 2, it was found that undergraduate students had difficulty in managing asynchronous discourse. (We will discuss the reasons for this later). Typical discourses seen in Community C were simple turn-takings such as qualification–request–qualification and claim–request–claim. Someone asked a question and then another answered it in such threads. However, as learning went on, a few important discourses were evaluated as progressive by university professors. Appendix C shows such a discourse framework. The thread consisted of eight notes by four students and the instructor over a period of 18 days. They debated: (1) how we transfer our knowledge and (2) whether there are general strategies for knowledge transfer. They discussed the mechanism of knowledge transfer and then debated ideas of domain-specific principles of knowledge and general problem-solving strategies to reach a shared understanding.

The argument framework in the undergraduates' WebCSILE discourse suggests to us that novice learners had difficulties in engaging in knowledge advancement. However, they could gradually adapt themselves to the new environment by collaboratively articulating their discourse. This result suggests that learners will create their own cultures of learning when they are exposed to a new learning environment. This culture will be more productive if the students have learning or knowledge building goals and if they receive sufficient support both from the system and their instructors.

Discussion

In Study 2, we deployed WebCSILE in an undergraduate course for the purpose of investigating how novice learners could make use of the new asynchronous communication tools to advance their knowledge and how they coordinated their different communication channels to make their discourse more productive or progressive. Even though they did not frequently engage in asynchronous discourse, it was found that even novices could gradually create a culture of learning as they kept on using WebCSILE. Here, through the comparisons of results between Study 1 (experts) and Study 2 (novices), we attempt to speculate on some crucial factors that would make the novices' knowledge advancement more productive.

First, even though the undergraduate students were engaged in both synchronous and asynchronous communication, it was found that the role of their synchronous channel was quite different from the graduates' in its quality. As we discussed in Study 1, the graduates recognized different roles of synchronous and asynchronous communications in their activities. Students in Community A managed synchronous communication to clarify directions of discourse that could be conducted in their asynchronous communication. Students in Community B clearly felt that they had missed such a discourse when they had been engaged in asynchronous communication only. In contrast, the undergraduates in Study 2 did not report the importance of different roles for the two channels. From our participatory class observations, we found them not to be involved in metacognitive or reflective discourse on their written discourse. Further, as stated in our sociometric analysis, their communication maps in synchronous and asynchronous communications were totally different from each other. The results suggest that their synchronous communication was disjointed from their asynchronous communication. Although the synchronous and asynchronous channels were both helpful for them to expand their discourse among more friends, the availability of the two channels did not frequently lead them to more productive discourse.

Second, it was found that novice learners in the study had learning goals or task goals rather than knowledge building goals. The students attempted to "understand" what they had listened to in class, but they did not engage in knowledge building activities. A relatively large number of students in the course claimed that they did not sufficiently understand the purpose of writing their thoughts on the computer network. What they reported in WebCSILE was mainly what they thought, what they felt, and experiences they had related to the topics they had studied. These discourses were useful for them to reach a deeper understanding but not sufficient for them to manipulate their knowledge as objects. This may be because, to function like expert learners, novices may need numerous information resources, strategic knowledge to organize productive inquiry, and the ability to monitor their activities.

Information Resources and Background Knowledge. Compared with the graduate students as expert learners, the undergraduates as novice learners missed background knowledge in the domain that they did learn and discuss. The instructor provided them with four different cognitive studies as information resources and explained the basic concepts needed for the students to understand the studies. However, such information resources were not sufficiently organized and represented as WWW homepages in the system so that the students could reflect on what they had learned and what they had not understood. Thus, the materials provided to the students in synchronous and asynchronous communication were insufficient in their amount and structure.

Skills for Scientific Discourse. As seen in the comparison of discourse frameworks between novices and experts and the data from the questionnaire, the novice learners did miss some important skills for scientific discourse and strategic knowledge for managing their discourse, such as using metadiscourse. With respect to skills for scientific discourse, the novice learners did not recognize how to represent their thoughts through scientific discourse, for instance, based on an argument framework. Their discourse was not found to be progressive because it did not have references, claims, and rebuttals in particular. They seemed to hesitate to articulate thoughts in such a way that others could criticize or share their ideas. In addition, the novices did not take multiple perspectives on their problems. Consideration of problems from multiple perspectives naturally generates rebuttals and multiple claims. Through such multiple perspective taking, the experts further attempted to converge their thoughts through qualification, warrants, and backups.

With regard to strategic knowledge for scientific discourse, one of the most remarkable differences in discourse between the experts and the novices was that the novices did not clearly put metadiscourse (e.g., Crismore, 1990) in their writing. Strategic knowledge for metadiscourse was found to be important for participants in focusing on a specific aspect of an argument from a specific perspective. The graduate students as expert learners in Study 1 were mainly using two strategies of metadiscourse in constructing their discourse on the computer network. The first was a citation strategy, such as paraphrasing or summarizing discourse in their face-to-face or original arguments in their reading assignments. The second was an abstract strategy, such as digesting what they wanted to discuss in their writing. Through these efforts, they succeeded in keeping multiple perspectives on specific problems, which eventually converged into their shared understanding. In contrast, written discourse by the novices did not show these efforts. They did not clearly identify what problems they were discussing or how they would solve them. No one requested such a qualification or specification in their written discourse. We need to consider instructional support for improving novices' knowledge of their scientific discourse.

EDUCATIONAL IMPLICATIONS

Through the two consecutive studies, we have seen how expert or novice learners made use of a new technology (i.e., WebCSILE) in their learning contexts. The results in Study 1 investigating expert learners' activities showed that the expert learners recognized differences in qualities of synchronous and asynchronous communication. In struggling to coordinate the two channels, they employed the synchronous one to organize their thoughts so that they could follow up in the asynchronous channel. The results of the second study with novice learners showed that (1) some novices could gradually engage in their knowledge advancement discourse and recognize the importance of WebCSILE as a tool but that (2) their knowledge resources, such as domain-specific knowledge, skills for scientific discourse, and strategic knowledge for the discourse, were still insufficient for conducting knowledge building activities. In this final section, we discuss some ideas on instructional interventions for improving novices' discourse in the IT-supported learning environment.

Project-Based Learning. For novice learners, activities in a new IT-supported learning environment are not sufficiently organized because they require doing something new but do not specify exactly what to do. Novices need some guidance of what to do for what purpose. One observed difference in activities between experts and novices was that the experts saw their learning as problem solving or as a project to create shared knowledge. The novices, however, saw their learning as a product of their problem solving (Bereiter & Scardamalia, 1989). Unlike a naive definition of "projects," the experts' projects had some conditions. First, the projects they engaged in were generically collaborative. People who took different perspectives were welcome; then efforts were made to converge those multiple perspectives. The group consisted of people who had different expertise in their shared domain at different levels (e.g., Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Brown, & Campione, 1994). Second, projects were directed by knowledge building goals, that is, the expert learners did not see any final goals that ended their discourse. Rather, their problem solving activities were ill-structured or emergent goals-oriented. As they solved any problem, they then found new problems. Thus, their shared goals were to continue to advance their knowledge through their discourse.

To have novice learners conduct project-based learning as experts do, we have to prepare some activity guidance so that they can acquire different knowledge resources and then contribute to their discourse from multiple perspectives. The most typical pitfall in conducting such project-based learning may be that the organized activities are directed by clear, concrete goals such as creating products or finding one answer. If the activities are constrained by such goals, discourse would not be progressive or sustained. As found in the experts' activities in this study, we should focus the activities on knowledge building or creating arguments on their knowledge-based problems. This type of commitment to discourse is thought to be the most crucial factor for discourse in science (e.g., Bereiter, 1994; Popper, 1972). Face-to-face discourse should play a crucial role in managing the organized activities. As a metadiscourse channel, face-to-face communication would be used for monitoring total progress in knowledge advancement by learners and for providing opportunities for learners to exchange emergent problems that direct their progressive discourse in the future. Further, ITs such as CSILE would play the role of providing representations of discourse so that learners in the organized activities could reflect on what they have done and on their emergent goals.

Materials for Learning. We need to provide learners with the resource materials they need to conduct their knowledge advancement. There may be two streams of consideration that we should finally coordinate. The first is that the instructors' side should create such materials for learners. We expect the learners to construct their knowledge based on their learning the prepared materials. What we should keep in mind here is that we should not rigorously control the direction of their learning. All that may be required is to provide the basic materials by which learners can grasp the key ideas in target domains. The second is that learners themselves should search for and create materials for their own learning. For this to happen, we need strong search engines and material databases. WWW resources or any other mobile media are candidates. WWW resources prepared by reliable experts, in particular, may be a good resource of information in specific domains of interest.

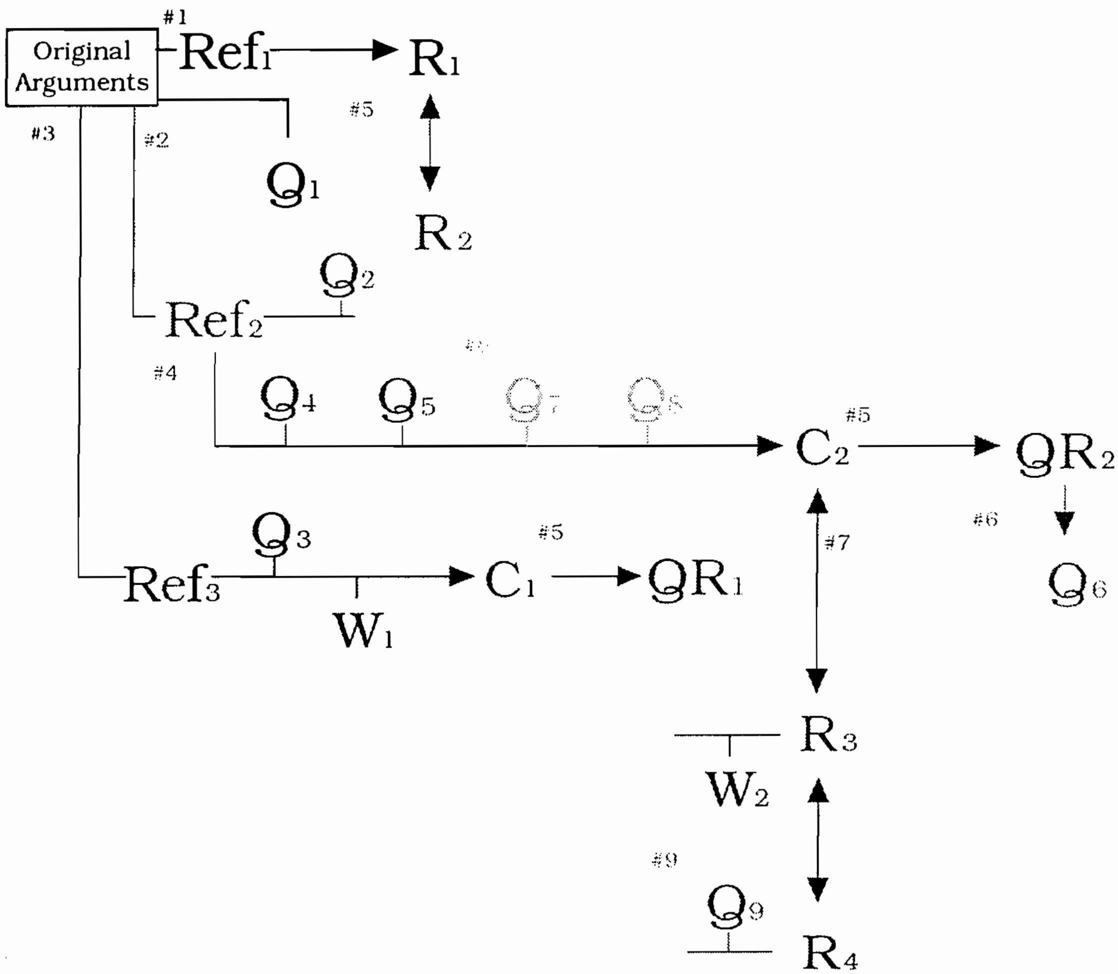
Construction of materials would be mediated through face-to-face and asynchronous discourse in learning. Learners can discuss what sorts of materials or resources are needed to conduct further knowledge advancement so that we as instructors provide some hotlinks to get necessary information on a WWW page. Further, in WebCSILE, learners can easily create hyperlinks to WWW resources in their notes. They, as learners, can create their own materials as they conduct knowledge advancement on a computer network.

Scaffolding for Scientific Discourse. From results in the studies, it was found that novice learners need scaffolding both for discourse skills and strategic knowledge. With respect to skills for scientific discourse, novice learners were found not to invoke a framework of discourse as arguments or to share knowledge objects with others. Although an example of rhetorical representation of scientific discourse, Toulmin's framework of arguments would work as a tool for us to create knowledge as an object to share and articulate. It may be effective to have novice learners use a specific framework of discourse such as Toulmin's as shared rules of representing their knowledge (e.g., Streiz, Hanneman, & Thüring, 1989).

Nonetheless, it seems fair to say that discourse for knowledge advancement does not happen only by providing novice learners with specific framework of discourse as rules. The discourse framework itself is just a rhetorical technique of representing our thoughts. The rhetorical representation should be articulated through reflective thinking by learners. For reflective thinking, we should support novice learners in improving their strategic knowledge for scientific discourse (i.e., comprehending, monitoring, and revising their discourse as arguments). In studies of discourse comprehension and written discourse, some strategic knowledge used by expert learners in learning have been articulated (e.g., Bereiter & Bird, 1985; Bereiter & Scardamalia, 1987; van Dijk & Kintsch, 1983). What these studies addressed is reflective manipulation of knowledge between rhetorical and content spaces, that is, metacognitive activities for creating arguments in scientific discourse. We think that the most important scaffolding by instructors is support for the metacognitive manipulation of discourse. We as instructors should consider how we can have novice learners participate in metacognitive manipulation of their discourse in face-to-face or asynchronous communication. In such efforts, knowledge media provided by technologies such as CSILE should work as powerful engines for instruction.

APPENDIX A

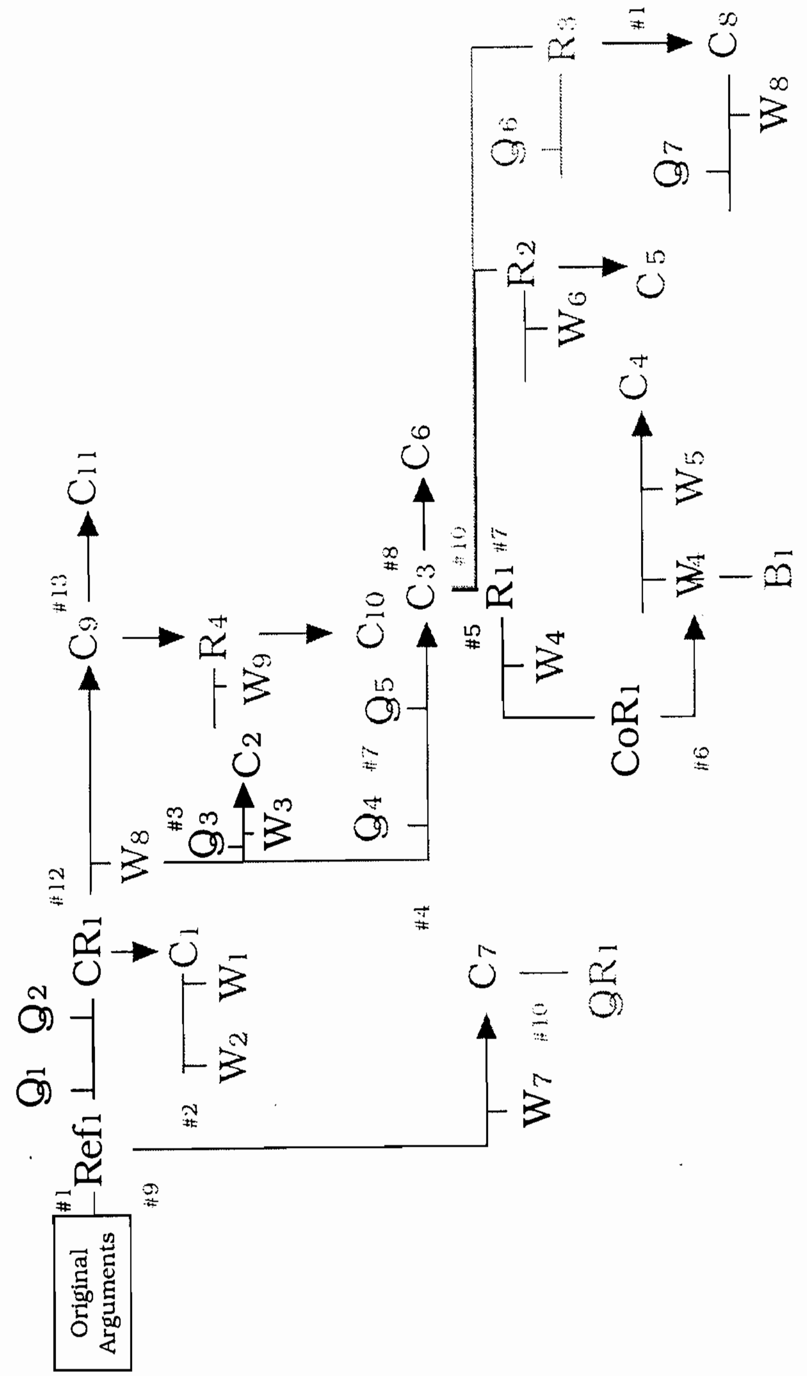
An Example Argument Framework of Written Discourse in a Thread by Community A[4]



APPENDIX B

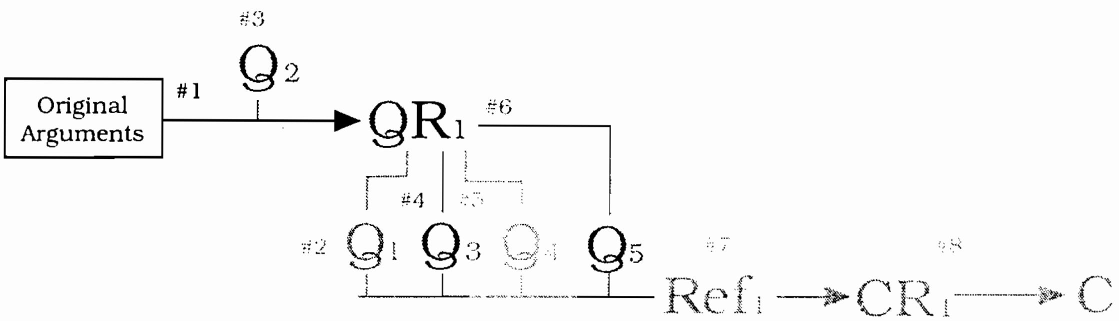
An Example of Argument Framework of Written Discourse in a Thread by Community B

Numbers with # show the order of notes to be reported. Ref, C, Q, W, B, R, CoR, QR CR represent Reference, Claim, Qualification, Warrant, Backup, Rebuttal, Confirmation Request, Qualification Request, and Claim Request, respectively.


Original Arguments
Ref1
CR1
CoR1
QR1
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
R1
R2
R3
R4
W1
W2
W3
W4
W5
W6
W7
W8
W9
B1

APPENDIX C

An Example of Argument Framework of Written Discourse in a Thread by Community C



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