Collaborative Learning Using Collaboration Technology: Report from the Field

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Abstract

We propose that emerging collaboration, or groupware, technology that supports synchronous interaction among students and faculty can add new aspects to the traditional distance learning and university course models. To explore this assumption we taught a masters' level university course using collaboration technology. In our approach, collaboration technology (integrated synchronous audio- and video-conferencing, electronic whiteboard and shared application tools) was used to provide students at universities in different countries opportunities to participate in interactive class exercises and discussions, and to do class assignments together. Students also participated in traditional, face-to-face class seminars, discussions and exercises at their local university. Thus students learned using collaboration technology and traditional methods.

In this paper we describe the course and discuss students' evaluations of the course, their collaboration with each other, and collaboration technology used during the course. Students evaluated the course and their collaborative experiences very highly but reported unique challenges and had mixed impressions with respect to the technology. Challenges included establishing interpersonal communication and meeting commitments. In general, students judged collaboration technology lower than e-mail and telephony in characteristics such as social presence, participation and ease of use. However, there were differences in evaluations among students in Chapel Hill and Oulu implying cultural preferences. In addition, students reported varying degrees of productivity and variety of tasks afforded the technology. These differences were similar for students in Chapel Hill and Oulu, implying individual preferences influenced evaluation of the technology. These results appear to imply that students need to learn principles of collaboration in addition to the technology for collaborative learning across distances to occur, and that a variety of technologies are needed to accommodate cultural and individual differences among students.

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1. Introduction

Business, government, academia and non-governmental organizations are increasingly relying on multi-national and multi-disciplinary teams to solve complex problems, and design and deliver new products and services. Collaboration has been recognized as a necessary and fundamental success factor in many organizations (Kantor, 1996). This will become increasingly important as we move to a global economy. Emerging collaboration technology, including groupware and computer-supported cooperative work (CSCW) applications, offers new possibilities to collaborate and promises cost-effective support for collaborative work.

A previous study shows that it can take up to 10 years for professionals to learn collaboration skills on the job, if they learn them at all (Sonnenwald, 1996). It has also been reported that without understanding the nature of collaboration in competitive and individualistic cultures, groupware on its own is unlikely to engender collaboration (Orlikowski, 1993.) Successful collaboration requires skills and knowledge about the collaboration process in addition to traditional, specialized domain knowledge. Collaboration, however, is not included in many academic and professional curricula. We believe there is a need to teach our students collaboration theories, strategies and tools.

To address this need, we combined and extended the traditional university course model and distance learning model to teach collaboration using collaboration technology. The traditional distance education model has four features: teacher and students are separated during a majority of the instructional process; courses take place within an educational organization and the educational organization influences the process; education media (technology) is used to unite teachers and learners and carry course content; and two-way communication is provided between the teacher and students (Roberts, 1996.) This model does not take into account communication among students at different locations and the possibility of students learning from each other. Rather it assumes teachers transfer information to learners using some educational media. However, new educational theories emphasize active and constructive learning that suggests learners should not be passive recipients of information (Linn, 1996.) Learners should integrate new information into their former knowledge structures. This occurs through interaction with others and application of new information in situations relevant to the learners. We propose, as do others, that emerging collaboration, or groupware, technology can add new aspects to traditional distance learning. Efforts to benefit from this new technology in distance learning have been carried out using audio-conferencing, video-conferencing (satellite and ISDN delivery), document sharing, e-mail, international relay chat (IRC), the world-wide web (www), etc. (Barron, 1996; Linn, 1996; Peterson Holland, 1996). The focus has been on technologies, not on the possibilities they offer to teach collaboration and to support collaborative learning.

Our focus was to teach collaboration across boundaries using collaboration, or groupware, technology. We synthesized and extended both the traditional university course model and distance learning model. In our approach, collaboration technology (integrated synchronous audio- and video-conferencing, electronic whiteboard and shared application tools) were used to provide university students in different countries opportunities to participate in interactive class exercises and discussions and to collaborate on class assignments. Students also participated in traditional, face-to-face class seminars, including discussions and exercises. Thus students learned about collaboration by reading and discussing aspects of collaboration theory, strategies and technology, and by using collaboration technology to complete exercises and assignments with students in another country.

In this paper, we describe our course offered during the 1997 spring semester at the University of North Carolina at Chapel Hill, North Carolina, USA and University of Oulu, Finland. We also discuss students' evaluations of the course, collaborative experiences during the course, and the collaboration technology used during the course. Students evaluated the course and their collaborative experiences very highly but reported unique challenges and had mixed impressions about the technology. Challenges included establishing interpersonal communication and meeting commitments. In general, students judged collaboration technology lower than e-mail and the telephone in characteristics such as social presence, participation and ease of use. However, there were differences in evaluations among students in Chapel Hill and Oulu implying cultural preferences. In addition, students reported varying degrees of productivity and variety of tasks afforded by the technology. These differences were similar for students in Chapel Hill and Oulu, implying individual preferences influenced evaluation of the technology. These results appear to imply that students need to learn principles of collaboration in addition to the technology for collaborative learning across distances to occur, and that a variety of technologies are needed to accommodate cultural and individual differences among students. Thus we propose a synthesis of traditional methods and collaboration technology appear necessary to enable students to benefit from increased educational opportunities made possible by the technology, and to be productive participants in a global economy that requires collaboration among organizations and nations.

2. Course Framework: Merging Traditional Methods and Collaboration Technology

During the spring semester 1997 the same master's level course in information studies was offered at two universities on different continents. The course, titled "Collaboration Across Boundaries," was taught at the School of Information and Library Science at the University of North Carolina at Chapel Hill, USA by one co-author (Sonnenwald), and the Department of Information Studies and Sociology at the University of Oulu by another co-author (Iivonen.) Eight students in both universities participated in the course. The students (10 female, 6 male) ranged in age from 22 to 53 years of age.

2.1 Course Content and Traditional Teaching Methods

The content of the course focused on collaboration among individuals, project teams, organizations and societies or large social groups, the state of the art in collaboration technology, and future prospects for collaboration. These topics are discussed in multiple disciplines and, thus, students were required to read and synthesize literature from communication, business, sociology and computer science that discussed theoretical and practical issues. For example, in learning how individuals collaborate, students read about interpersonal communication theories (Trenholm, 1991), examples of how to deal with difficult people (Bramson, 1981), and how to use e-mail to communicate effectively (Angell & Heslop, 1994). Separate lectures and discussions on the readings were conducted in Chapel Hill and Oulu.

Small group exercises were also used to emphasize key concepts and provide opportunities to practice skills. For example, to emphasize the role communication plays in collaboration, students were divided into small groups of four. Each group was given 15 to 20 minutes to construct an artifact (anything they wished) using Legos™ with no verbal or written communication, and noting what they would like to communicate if they could. The class discussion afterwards focused on students' different perspectives of the artifact that was constructed, the collaborative process and the type of information that facilitates collaboration.

When exercises were not feasible, case studies were used to help illustrate key concepts. For example, to learn about collaboration among large social groups and conflict resolution theories, a memoir of the collapse of Yugoslavia written by the last American ambassador to Yugoslavia (Zimmerman, 1995) was used. Furthermore, students had the opportunity to interact with "expert" collaborators. Visitors who had significant experience facilitating collaborative projects or working in collaborative projects visited the class and shared their experiences with students. The graded assignments in the course included a research paper or project done in collaboration with at least one student at the other university, and a presentation on the paper or project.

We augmented these traditional university teaching methods using collaboration and other information and communication technologies to provide students with additional learning opportunities.

2.2 Technology and Its Role

The technology we utilized in this course included asynchronous and synchronous tools. Asynchronous tools included electronic mail (e-mail), the world wide web (www), file transfer protocol (ftp), and electronic discussion boards and listservs. Synchronous tools included the telephone and collaboration technology, in particular MBone applications (Eriksson, 1994) and Microsoft® NetMeeting™ (Microsoft, 1997). MBone, the multicast backbone, is a virtual network on "top" of the Internet that provides a multicasting facility. Publicly available MBone applications provide video- and audio-conferencing and a shared electronic whiteboard among two or more UNIX-based PC's or workstations. Microsoft NetMeeting provides point-to-point video- and audio-conferencing and shared applications, such as word processing and spreadsheets, between two PC's running Windows 95™ or Windows NT™. Both systems use the internet for telecommunications networking.

During the course the asynchronous and synchronous technologies were used in a variety of combinations to support asynchronous information dissemination, synchronous group exercises and discussions, and asynchronous and synchronous collaborative work.

2.2.1 Asynchronous Information Dissemination

Asynchronous information dissemination and communication was facilitated through a course home page on the www. The course home page included links to traditional class information such as the course syllabus, descriptions of the course objectives, policies and assignments, and a glossary of terms found in the assigned readings. The home page also included links to dynamic information tools customized for the course. These tools included participant profiles and discussion board/listservs.

During the first class sessions, students expressed an interest to learn more about their colleagues in the "sister" class. In response, the students in Chapel Hill and Oulu developed a list of personal biographical information they wanted to learn about their colleagues and would be willing to share about themselves. This information included: personal information (name, e-mail address, homepage address, age, home town, family size, martial status, hobbies and personality type[1]); background information (educational background, professional background and academic/career goals); thoughts on collaboration (previous experience collaborating, motivation for taking this course, general interests in collaboration and proposed topics for research papers required for the course); and any additional information an individual would like

[1] As determined by the Kiersey Temperament Sorter (Kiersey & Bates, 1984).

to share, including links to other web pages. A student (Alpi) designed and developed an interactive web-based form page that queried students for this information. The information was then incorporated into web pages featuring students and instructors. This was a first step in establishing communication between the two groups of students.

A discussion board and associated listserv were used throughout the semester to share pointers to additional resources, discuss course-related topics and interpersonal communication. Interpersonal communication, or "small talk," including discussions about Valentine's Day, President Clinton's visit to Helsinki, local sports events, etc. When a message was posted to the discussion list, each class participant was notified. Each message was archived and could be accessed, and responded to, from a web page. A total of 128 messages (from 16 students and 2 instructors) were posted during the semester; 80 messages were posted by students in Chapel Hill; 36 by the instructors; and 12 by students in Oulu. We suspect that the differences in these numbers are due, in part, to technical problems in accessing the class discussion page from Finland (slow international network transmission speeds and scheduled equipment and line maintenance in the US meant daytime access in Finland was difficult). Other reasons may be cultural-based. "Small talk" is not a Finnish tradition and thus can be awkward for Finns to do electronically.

2.2.2 Synchronous Group Exercises and Discussions

We used MBone tools to facilitate interactive groupwork exercises and discussions. These tools also support video-conferencing in the traditional long-distance education mode (i.e., one-way lecture with some question and answer periods). However from our point of view this approach does not sufficiently engage students. Instead students used the technology to participate in real-time interactive small group exercises and discussions, although physically there was an ocean and 7-hour time difference between their locations. However, there can be difficulties in achieving this. In addition to technical difficulties discussed earlier, even enthusiastic and dedicated students sometimes need gentle introductions to new technology.

To introduce students to the capabilities and limitations of this technology, students[2] participated in class exercises using MBone applications. For example, the class in Chapel Hill was given the task to design a residence for aliens on another planet. One-third of the class was assigned the role of "user representative." They were given specific information about the needs and constraints of the users, i.e., the aliens. One-third of the class was assigned the role of "project leader." They were given information about management's expectations with respect to the project. One-third of the class was assigned the role of "architect." They were given specific information about building materials. Each group went to a different location on the university campus. They "met" using collaboration technology. That is, each group used a workstation with audio- and video-conferencing capabilities and shared applications to work with the other groups to complete their task. Students working face-to-face can usually complete this task in 60-75 minutes. However, using MBone technology the students were unable to develop a solution. We met face-to-face afterwards to discuss the limitations of the technology and strategies to work through these limitations.

As a result of these experiences, students became familiar with the mechanics of the technology, and identified criteria to evaluate collaboration technology from a human information behavior perspective, including social presence, degree of participation afforded, multiplicity of tasks supported, productivity gains, and ease of use.

[2] Note, due to technology constraints, only students in Chapel Hill had this opportunity.

We chose less complex, team building exercises for the first Chapel Hill-Oulu interactive session for several reasons. The students had not previously met or worked together; we were not certain the technology would work reliably; some Finnish students were hesitant about speaking and understanding English (although they did it very well); and, it was clear from the previous exercises in Chapel Hill, more complex tasks are difficult for students to complete using the technology. The first exercise focused on working styles; the second meeting effectiveness (Bendaly, 1996).

In the first exercise, students were divided into pairs and each had to identify work style characteristics they preferred. Based on their responses, their partner then suggested their work style was more task or process-oriented, or balanced. The student pairs were decided ahead of time by the instructors; some care was given to personalities. Students also had the option of beginning the exercise via e-mail (all but one student did this.) In this way, students began to learn about each other and formulate ideas about how they could work together collaboratively.

The second exercise focused on identifying factors that affect meeting practice. Exercise goals included increasing students' knowledge about their work preferences. Students were given a list of meeting characteristics, or factors (e.g., "everyone participates", "discussion stays on track", etc.) (Bendaly, 1996.) They were divided into small groups of 4 (2 students from Oulu, 2 from Chapel Hill) with the goal of identifying the five characteristics most important to them. Again, students had the option of beginning their discussion via e-mail. During the joint, interactive class session, each group "met" for 20 minutes using MBone technology. Afterwards the classes "met"; each small group reported their results and, as a large group, we identified the top 7 characteristics shared by almost everyone. A challenge for students was to operationalize these preferences as they collaborated on course assignments.

The technology posed several limitations on these discussions. The MBone audio tools are not fully synchronous in the same sense as the telephone. That is, only one person can effectively speak at a time[3]. The internet audio and video transmission speeds and quality (successful packet transmission rate) are sufficiently low such that words spoken close in time at different locations are often heard at the same time in other locations. In addition, syllables may be dropped during transmission and never heard. This can be especially challenging when trying to understand individuals who speak with an accent or dialect different than yours. Participants must usually check before beginning to speak to ensure no one else will be speaking at the same time. If people from different locations speak simultaneously or almost simultaneously, neither can be well understood. Typically in face-to-face conversations we deal with these problems by observing others' behavior. This is not as easily done with MBone video. With slow transmission speeds and possible packet loss, the video picture you observe may have a several seconds (or minute) delay, and lack details needed to determine if the person is about to speak or not. To work around these issues, we used several coping behaviors. One such coping behavior was announcing who would speak next; everyone would pause until that person finished. Another coping behavior was speaking in "bursts" as done in short-wave radio. That is, students would need to say what they wanted to say and then be quiet. The technology could not support the normal short phrases that a student might typically add-on (after a brief pause) to their question or comment.

[3] If open microphones are used, multiple people can speak from one location but voices and words are not distinguishable; a collective "Hello!" or "Good-bye!" can be communicated but little else.

Another limitation is that the electronic whiteboard only allows a single user to write on the board. Each user must serially add to the whiteboard. The analogy of several people with different pens writing on a common whiteboard is not supported. Furthermore, when the whiteboard is used, audio cannot be transmitted. It's an "either or" feature; either you write on the white board or you can speak/transmit audio, not both. Again, these limitations require work-arounds or coping behaviors. One such behavior we used was to use the video to transmit text and graphics. This allowed writing and audio to be transmitted simultaneously. With this solution we relinquished the ability to see one another but, similar to other research in multi-media communications, we found that acceptable.

Despite these limitations, we could not have offered the course without using MBone technology. We when offered the course it was the least expensive way to support real-time n-way interaction across distances. The software is free, as are network connections. Often audio quality rivals telephony audio quality; video is an added bonus.[4]

2.2.3 Asynchronous and Synchronous Collaborative Work

Students were required to collaborate with other students, at least one of whom was in the "sister" class. They were required to complete a paper or project together and present it to the class. Paper topics focused on various aspects of collaboration and collaboration technology and included: evaluation of CSCW technology from a human information behavior perspective; an evaluation of virtual galleries; the importance of respect in collaboration and how respect is, and is not, afforded in groupware; the creation of a one-day workshop to teach collaboration skills to professionals; and sharing cultural information through collaboration.

To collaborate on their papers, students used asynchronous and synchronous technologies. E-mail was used most frequently. However, students had the option of using MBone or NetMeeting. The students primarily used the audio and shared application features of these tools. Students also used the www and file transfer protocol (ftp) to share versions of their papers; individual project discussion boards to discuss ideas and issues related to their paper; fax to share copies of relevant articles and their work; and the telephone to discuss issues privately. In sum, they used all technology they had access to in creative ways to complete their papers.

Each group successfully completed a paper. Two papers have been expanded and will be presented at international conferences; a project that focused on teaching collaboration is being used to teach groups in Central America. Students had the option of making an individual presentation to their local class or a joint presentation to both classes (using MBone technology.) All students opted for a joint presentation.

3. Methods to Evaluate Collaborative Learning Experiences and Technology

In this course we introduced two new elements: collaborative learning across boundaries and collaboration technology. Standard course evaluations used in higher education in the US, such as the student instructional report (ETS, 1973) capture students' perceptions of the

[4] Packet loss occurs on the internet and video transmission, in particular, is subject to delays and broken connections because it requires continuous, high-speed packet transmission. Audio uses fewer and less frequent packets (in comparison) and, as a result, audio quality was generally higher. As illustrated in media studies (e.g., Reeves & Nass, 1996), audio quality is more important to participants than video quality, and we found this to be the case as well.

instructor and assignments but are not sufficient to capture students' perceptions of collaborative learning experiences and collaboration technology. Therefore we used two data collection methods to understand students' perceptions.

To gather data on students' perceptions of the collaborative learning experiences during the course students were asked to reflect on their experiences. Students were prompted to think about "what worked well, what didn't work well, things that surprised you along the way, things you might try the next time you collaborate, challenges that emerged and your response to those challenges." Students were required to submit written responses but were not graded on their responses. This method provided qualitative data; descriptions of students' perceptions of their collaborative learning experiences, expressed and explained in their own language.

Critics of qualitative research sometimes say that its findings "typically sound like interpretations, totally contingent on time, place, and person" (D'Andrade, 1986, p. 26). We view this as a strength rather than a weakness: interpretation and contingency are the fundamental bases of human experience, of learning and knowledge creation. How better to understand the process and outcomes of collaborative learning than by explicitly incorporating hermeneutic, or interpretive, processes into the analysis?

Students' perceptions of technology, including MBone, NetMeeting, e-mail and telephony, that were used in the course were evaluated through a survey instrument. As discussed previously, during the course students suggested a variety of evaluation criteria. The criteria build on previous research and their experiences using the technology.

In addition to the traditional time-place CSCW evaluation continuum (e.g., see Khoshafian & Buckiewicz, 1995) and "ease of use" and "productivity" criteria used in human-computer interaction literature (e.g., see Landauer, 1987), criteria such as: social presence afforded; user control (is control among users shared or whether someone has complete control); degree of participation afforded (can each user participate fully or are there limitations that prohibit full participation); multiplicity of tasks supported (does the technology support different types of tasks); group work styles supported (is a single or multiple types of work styles supported); physical requirements (what the tool requires in terms of human physical needs or how difficult or easy it is to use the tool); and tool flexibility (does the tool allow or support changing, or dynamic, work styles and tasks). Students (Alpi and Kokkinen) developed a survey instrument that incorporated these criteria. Students evaluated MBone, NetMeeting, e-mail and the telephone/conference call by rating each criteria along a continuum scale. A continuum scale was chosen because this scale allows greater flexibility in responses and illustrates interpretative patterns and trends more so than a Likert point scale (Bystrom, 1995.) All students completed surveys (n=8 in Chapel Hill; n=8 in Oulu.) A sample size of 16 is not sufficiently large for statistical analysis; additional data must be collected when the course is offered in the future. Given this limitation the completed surveys were analyzed in the hopes of identifying patterns, or clusters, of similar and dissimilar responses. All responses for each tool were merged and co-located on a continuum scale for each criterion. Patterns of responses were then identified among the data. Due to space limitation in this paper, we will focus on students' perceptions concerning social presence, participation, tasks, productivity and ease of use.

4. Collaborative Learning Experiences: Students' Perceptions

Challenges and benefits of collaborative learning using collaboration technology emerged from our analysis of students' retrospective reports. Challenges included developing interpersonal relationships to help facilitate collaboration, and maintaining a high level of commitment to the

group and group task. Benefits included improved outcomes and personal growth.

Interpersonal communication has been identified as important for collaboration in other contexts (e.g., Sonnenwald, 1996). Our data suggest that interpersonal interaction is important for collaborative learning across distances as well. Students found it difficult to "get to know one another," perhaps because there were no opportunities to interact informally face-to-face. In addition, there were cultural differences among students that are usually not as prevalent in courses offered in one location. These challenges are introduced, or become more problematic, by our application of the technology, and are not solved by the technology. It appears that additional effort is required to establish interpersonal relationships. Students reported:

> It was very challenging to do the paper with someone, who was in another country and who you did not know anything about at the beginning. We both realized that the social part of collaborating is very important, and you must give time to that unofficial part. Both of us took time to try and get to know each other better. That helped the project go more smoothly.
>
> The tools do not collaborate themselves. A good personal relationship is crucial...there were technical problems and human misunderstandings...but eventually we established an effective and rewarding partnership.
>
> Collaborating with new technology requires more attention to...cultural aspects, getting to know the working style of the partner and taking some time to decide the rules and ways for working together.
>
> The tools that were available to us do not approach substituting for the interpersonal interaction that distance precluded.

Commitment is another theme that emerged from students' reflections. Collaborative learning through technology appears to require additional commitment from students. For example, students reported:

> Collaboration is...something that needs commitment from those participating. For that I had some trouble...every electronic mail I sent had in it the word "tomorrow."
>
> Commitment to a project is very essential. When you commit to a project, you want to have good results; the responsibility comes together with it.
>
> This project has really shown me the importance of responsibility and commitment as a team or group member and the amount of effort it takes to succeed.
>
> If I were doing this all over again I would certainly be more diligent about it.

The theme of commitment surprised us. We perceived our students to be highly motivated, both internally and externally. For example, students actively participated in class discussions and stayed after class to continue these discussions. The course received some publicity on

our campuses and in the local press; students were featured in news articles and university promotional materials. Our students reported that other students were envious. Yet even with this high degree of motivation, students reported difficulty in establishing and maintaining a commitment to collaborative learning across distances.

A premise of collaborative learning is that it leads to improved educational outcomes, such as increased knowledge and personal growth. A question is: does collaborative learning using collaboration technology also led to improved outcomes? Technology, especially emerging technology that occasionally fails, may negate the benefits of collaborative learning. However, students' reflections provide evidence that educational benefits can be realized using collaboration technology. For example, students reported:

> I cannot say enough about how this project has forced me to grapple with the abstract concepts of doing collaborative work. I have had plenty of professional experience in working collaboratively having managed a million-dollar business with 30 employees... While I was forced to learn collaboration skills, in many ways this project gave me a more appropriate model and vocabulary for thinking about how successful collaborations can be achieved.
>
> According to Bendaly's [1996] 'Personal Workstyle Assessment', one of us could be described as more process-oriented, and the other, more task-oriented. The process-oriented partner was full of ideas and very communicative, while the task-oriented one shaped the structure of the project on the basis of those ideas. These characteristics complemented each other, leading to better results than either of us might have expected.
>
> This course has been a great experience at least in two ways. First, it has provided me with a theoretical framework and deeper understanding of various aspects of collaboration...Second, collaborating with a person abroad through the new collaboration technology gave a real practical insight into the subject...As a person, this course has taught me a lot about collaboration and myself as a collaborator.
>
> [The course] provided an opportunity for personal growth as well as academic growth. This is one of the most exciting adventures I have been on in a long time.

Students' perceptions of collaborative learning using collaboration technology provide support for continuing to investigate this approach. To build on the exploratory results reported here, future research could include teaching multiple sections of the course with and without technology, and comparing students' perceptions of outcomes and independent evaluations of student assignments.

5. Students' Perceptions of Collaboration Technology

Students' evaluation of collaboration technology, in particular, MBone, NetMeeting, e-mail and the telephone/conference call, are illustrated in Figure 1. All students in Oulu (n=8) and Chapel Hill (n=8) class participated in the survey. To provide an overview of students' perceptions of the technology we focus our discussion on students' evaluation using 5 criteria: social presence, participation, choice of task, productivity and ease of use.

S*ocial presence*, or sense of presence, is the degree to which a communications technology is perceived as conveying the presence of participants (Short et al., 1976). It is a subjective concept that asks whether the interaction is personal, sensitive, sociable and warm. These qualities are proposed to affect performance outcomes. Rice (1992) has proposed that a sense of presence is more difficult to achieve through computer-mediated communication because non-verbal communication, such as eye gaze, kinesics, and proxemics, is missing. Tasks that involve creative, interpersonal, emotional and outcome-oriented activities may require communication media that provides a strong social presence, whereas tasks that involve relaying information, especially time-sensitive information, may not (Rice, 1993). Therefore, in educational settings, the degree to which a technology affords a sense of presence may influence learning outcomes.

In general, students in Oulu felt that MBone and NetMeeting provided a fuller social presence than did students in Chapel Hill. Both groups felt e-mail provided a somewhat limited social presence. Surprisingly, students in Chapel Hill felt the telephone provided a strong social presence; students in Oulu rated the telephone, MBone and NetMeeting similarly.

These results appear to indicate that the Oulu class more highly valued video-conferencing, electronic whiteboards and/or shared applications than the Chapel Hill class. Several Finnish students suggested this is because in their culture they are more used to collaborating in face-to-face situations than in situations using computer-based tools that do not allow you to see your partner. Thus, they more highly value video and other visual connections when collaborating across distances. This may also be significant for other cultural groups in the USA and other countries that have a stronger face-to-face tradition. An alternative explanation may be that students in Chapel Hill had higher expectations for the technology but the technology did not meet these expectations and hence the lower rating. However, we believe this is less

likely because both groups are university students in similar academic programs with similar curriculum and have had similar exposure to information and communication technology.

Participation in group work is important if all group members are to contribute to and benefit from the learning process. Does the technology allow each user to participate fully? There can be varying degrees of participation from full to none. Although all students thought the telephone generally afforded a high level of participation, students in Oulu rated MBone and NetMeeting as affording slightly higher levels of participation than did students in Chapel Hill. Again, this perception may be influenced by the Finnish culture that values face-to-face meetings, and perhaps their surrogates, highly. Students in Chapel Hill rated e-mail as supporting more participation than students in Oulu but not significantly so. This rating is reflected in their more frequent use of the listserv to communicate with everyone in the class. However, in general, students rated telephony as providing the highest degree of participation.

These results seem to imply that synchronous technical capabilities in conjunction with social conventions, or norms, are required to provide a sense of full participation for many students. In the case of the telephone, social conventions have been developed to facilitate turn-taking, interrupting, etc. These conventions do not necessarily transfer easily to MBone and NetMeeting and the technologies do not themselves explicitly afford participation. For example, an interjection such as “yes, and ...” or “yes, but ...” often can not be heard or can not be heard in a timely manner using MBone or NetMeeting, and the tools do not provide other capabilities to compensate.

An issue for educators concerns the *variety of tasks* that are supported by technology. We often prefer educational goals and not information and communication technology to dictate the type of tasks we assign students. Most students reported that e-mail strongly dictates the type of task the technology supports. Students in Oulu judged telephony similarly. However, the students in Chapel Hill reported a wider range of responses for telephony; two students perceive telephony is open and does not dictate the choice of task. For NetMeeting and MBone, responses from students in Oulu and Chapel Hill were widely scattered along the continuum. Individual, not cultural, differences appear to affect students’ evaluations in this instance. Several students perceived MBone and NetMeeting as supporting a wider choice of tasks but that for some, the variety is not much greater than the choice supported by telephony. Thus the new emerging collaboration technology appears to offer some advances but, perhaps, more tasks should be supported.

Productivity gains realized through the use of technology is important to consider in many settings. In our setting, the issue was: does technology make the collaboration process and/or tasks easier, or more difficult, to complete? Technology often promises enhanced productivity and yet may not increase end-users’ productivity. Students in Chapel Hill rated productivity with e-mail and telephony as high. Students in Oulu also considered productivity with e-mail as generally high but had mixed feelings about the telephone. They thought e-mail was generally more productive because it affords them time to think about how to answer and express their own ideas. In fact, students in Oulu rated MBone, NetMeeting and telephone productivity very similarly. The students’ in Chapel Hill perceptions with respect to MBone and NetMeeting were more varied, ranging from high to low with no evident consensus. Thus, for all students, e-mail was perceived as the most productive technology in general. American students in general found the telephone to be more productive than MBone and NetMeeting. This, again, illustrates a cultural difference; American students found the telephone generally more productive than the collaboration technology that provided audio- and video-conferencing and shared applications. However, both classes indicated that the collaboration technology did allow for increased

productivity. The degree to which productivity rated varied among individual answers but the variation was largely consistent for MBone and NetMeeting. We suspect that individual differences may play a role in this evaluation. For example, individual work styles and/or cognitive styles may influence how students perceive the productivity of a tool. Further research is required to explore this issue.

Ease of use is important to evaluate in addition to productivity. When technology is not easy to use, instructors may need to spend additional time and effort teaching and convincing students to use the technology. In this study we found that students in Oulu and Chapel Hill gave the telephone and e-mail high marks for ease of use. These ratings may reflect the maturity of these technologies and/or students' familiarity with them. Students' ratings of MBone and NetMeeting varied. Some students in Oulu and Chapel Hill found MBone almost as easy to use as e-mail. However, most students found it harder to use. In general, NetMeeting was rated slightly easier to use by students in Chapel Hill than in Oulu. However, the ratings are widely dispersed and thus this observation may not be generalizable. These results appear to imply that the human-computer interfaces of collaboration technology need to be improved for use in educational settings. In the meantime, instructors may need to spend additional time and effort teaching and convincing students to use these tools because students may perceive them as hard to use.

In summary, when comparing responses from the two classes we see many shared perspectives with respect to tasks, productivity and ease of use afforded by these technologies, and differences in perspectives with respect to the social presence and participation afforded by the technologies. These results may be indicative of the role cultural differences play in distance learning. The technologies made collaborative learning possible but not always easy. As students observed:

> Collaborating with new technology requires probably more attention to delays than other forms of collaboration given the problems with time limits or equipment. Some cultural aspects, getting to know the working style of the partner and taking some time to decide the rules and ways for working together [are important.]
>
> [My partner] and I climbed into a cyberspace sandbox together, and through the miracle of communication technology and collaborative tools, were able to create our own little sandcastle...Thank you for this opportunity!

6. Discussion

Additional research, e.g., surveying students in similar courses in a variety of cultural settings, are required to increase the validity and generalizabilty of our results. However, qualitative and survey data from students in this course are complementary and merge to provide a view of the strengths and limitations of collaboration technology and its use in higher education.

Challenges that emerged from the qualitative, retrospective reports by students focused on the difficulty in establishing interpersonal communication and the high level of commitment required to collaborate. Interpersonal communication was difficult but eventually possible; collaboration always required a high level of commitment. These challenges are reflected in students' evaluation of the technology. In surveys, students reported collaboration technology does not necessarily afford a strong social presence or participation. It is also more difficult

than other technologies for many students to use. The students' evaluations were not unanimous in their ratings of technologies; patterns suggest both cultural and individual differences.

These results imply that a combination of technologies, including telephony and e-mail, should be available for student use to accommodate cultural and individual preferences. The emerging collaboration technology (specifically, MBone and NetMeeting) do not currently appear to be sufficient to support collaboration and collaborative learning by themselves. Although the ease of use of this technology may improve over time (e.g., with improved human-computer interfaces), it is not clear that it will be able to provide a stronger sense of social presence in the future. For example, synchronous video and audio over dedicated, high-speed networks designed and implemented by leading researchers in this technology has also been rated low in social presence by users (see Rice, 1993). Yet social presence has been rated as necessary for tasks such as getting to know someone, generating new ideas, resolving disagreements, making decisions, exchanging confidential information, exchanging information, negotiating and bargaining (Rice, 1993). Therefore we propose that collaboration technology should be augmented with traditional technologies such as telephony and e-mail. This allows students to work with familiar technology and accommodates individual and cultural differences.

These results further imply that instructors should consider teaching collaboration principles as well as providing activities to help foster interpersonal communication across distances. Reading assignments and class discussions exploring collaboration principles and exercises that require students to interaction with each other and get to know each other are possible ways to achieve this. The discussions and exercises may require additional course time than would normally be spent to teach a technology or develop interpersonal communication among students. However, the data suggest that the time and effort are warranted especially when cultural (and geographical) differences among students exist.

An additional technique to overcome the limitations of collaboration technology is to provide an instructor at each location. In our course, a faculty member at each location participated in the design and implementation of the course. This approach had several benefits. From a practical perspective, it allowed administrative and technical challenges to be handled by a local person who had insider's knowledge of administrative policies and procedures. From a pedagogical sense, the content of the course and its delivery was enriched through faculty collaboration. It also allowed the course to be tailored to the needs of students at both locations. Furthermore, the local instructor was able to encourage and support students in meeting challenges during the semester. When establishing interpersonal communication with, or keeping a commitment to, a colleague at another university was difficult, it was always possible for each student to interact face-to-face with a faculty member to receive guidance and encouragement.

Overall, we believe the course and the collaboration technologies used in the course provided students with a valuable education experience. As evidence by their retrospective reports, survey data, and completed course assignments, many kinds of learning took place. Students learned about emerging technology, and about collaboration from theoretical and practical perspectives. The collaboration technology provided educational experiences not previously possible. However, to realize benefits from the technology and effectively compensate for the limitations of the technology, we believe students should be taught principles of collaboration, including accountability, trust management, commitment, respect, tolerance and appreciation of differences, adaptability, knowledge sharing and interpersonal communication skills. Without such understanding, collaborative learning through collaborative

technology may not be possible. Thus a paradox emerges. The use of collaboration technology in higher education does not appear to eliminate or reduce the need for faculty, faculty-student interaction and other traditional teaching methods. These are still required to enable students to benefit from the increased educational opportunities made possible by the technology, and to be productive participants in a global economy that requires collaboration among organizations and nations.

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