

VIDEOCONFERENCING AND PRESENTATION SUPPORT FOR SYNCHRONOUS DISTANCE LEARNING

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Abstract — Synchronous distance education can partner students and professors from different geographic or cultural regions, allowing them to share and learn from each other. Technology must support the sharing of ideas and materials. Using an iterative design approach, we investigated challenges in synchronous distance learning environments through observation of Masters-level courses connecting two learning sites. Through observations, interviews, and surveys we learned of two major challenges: 1. Low-quality audio/video makes interaction difficult and 2. Presentation technologies in distance learning environments make extemporaneous teaching difficult. We developed and deployed a new distance learning system using internet based video conferencing and a pen computer based presentation system. We studied system use in a Masters-level course. Analysis of qualitative data (observation notes, surveys, interview transcripts) collected in the course suggest that technological interruptions increased the feeling of separation between the sites, while the integration of natural handwriting with slides increased flexibility and was perceived positively by students and instructors.

Index Terms — Distance Learning, Iterative Design, Presentation Technology.

INTRODUCTION

Distance education joins diverse perspectives, bridges geographical divides, and provides learning opportunities for people without physical access to a local college.

Synchronous distance education connects students and instructors via real-time communication. Typically, audio and video links connect the distributed learning sites, supporting cross-site discussion. For interaction to be successful, distance education environments must take the “distance” out of the education. Technology must support fluid conversation. Synchronous distance learning has benefits over watching a pre-recorded video of the instructor only when students learn from each other and from the instructor through interactive episodes.

To better understand the challenges in creating interactive distance learning environments, we studied a distance learning environment for Masters students at a large university. We observed the classroom, interviewed instructors and students, and surveyed instructors and

students to learn about their experiences. Our studies informed the design and deployment of new distance learning technologies, ConferenceXP and Classroom Presenter, to better connect students across learning sites and foster extemporaneous teaching with a flexible presentation system. By studying a distance learning course, we learned how the systems shaped the classroom community while gathering more evidence of additional technical and cultural challenges. The paper structure reflects our process.

ORIGINAL LEARNING SETTING & TECHNOLOGY

We studied the distance learning environment for a Masters courses in Computer Science at a large university. An author observed class sessions for Architecture and Cryptography courses. A more in-depth qualitative study took place in the Cryptography course; we collected observation notes, conducted interviews with the instructors and students, and created weekly surveys for instructors and students [1].

The distance learning course joined two learning sites: a local site on the university campus and a remote site at a large software company. The instructor delivered lectures at the *local* site, while a video image of the instructor and the lecture slides were displayed at the *remote* site. Each site was equipped with dedicated video conferencing equipment, cameras and microphones. The instructor wore a personal wireless microphone. The local site could view students at the remote site on a video display; however, the remote site viewed a single video image display of the instructor. PowerPoint slides served as the lecture medium. For extemporaneous writing, the instructor used a Smart Board; the electronic board display was transmitted to the remote site. Since the Smart Board was physically separate from the PowerPoint slides, the instructor could project either the Smart Board display or the slides. Microsoft NetMeeting connected the local computer display to the remote site.

Two instructors co-taught the Cryptography course, generally with one instructor delivering the lecture at the local site and the other present at the remote site. The distance learning course is not typically staffed by two instructors, and we hope to support the scenario of a single instructor at the local site. The Cryptography course served approximately 20 students at the remote site and 30 students at the local site. The course serves working professionals; therefore, the course met once per week for three hours.

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CHALLENGES IN ORIGINAL SETTING

The existing technology and course setup suffered challenges with respect to fostering interaction and supporting flexible presentations.

Faculty and Students

We asked faculty, who had taught distance learning courses, about presentation systems. From the eight respondents, it was clear that the presentation technology must support a variety of teaching styles. A major issue was the inability to respond in a flexible manner to the students while giving slide based lectures. Table I shows the responses regarding flexibility in presentation. Most faculty would like to highlight and annotate slides, but most were hesitant to choose a style. Instructors remarked about the reliability of the whiteboard technology. For example, a faculty member would use the Smart Board if "handwriting was captured more accurately." Another was concerned about viewing slides and the whiteboard simultaneously, since viewable space is restricted to the size of the projection screen.

Even though we asked faculty about presentations, they commented on the communication technology and interaction levels. Concerning the technology, one person commented, "I found the lag time in the teleconferencing system to be annoying enough that I couldn't/didn't break the activation energy to engage the remote students in discussion. This also decreased interaction with local students." Another faculty member commented that the audio quality needs to be as good as radio in order to comprehend the remote voices. The faculty made it clear that technology plays a large role in how lectures are delivered and how students participate in the classroom.

TABLE I

RESPONSES FROM EIGHT FACULTY WHO HAVE TAUGHT A DISTANCE LEARNING COURSE REGARDING FLEXIBILITY IN PRESENTATION STYLES

Question	Yes	No	Maybe
Would greater flexibility to annotate/highlight slides be useful?	5	2	1
Would you prefer to give a whiteboard style of lecture?	1	1	6

We also surveyed students who had taken a distance learning course (10 local, 5 remote) The satisfaction of the videoconferencing was similar for the local and remote groups with ratings of 2 and 3, respectively (0 -- completely unsatisfied to 6 -- completely satisfied). The local site gave a median rating of 4.5 for the presentation technology and 5 for teaching style while the remote site gave a median rating of 3.5 for presentation technology and 4.5 for teaching style. The challenges listed by the students include: poor reliability with videoconferencing connection, lack of participation of distance learning students, need for better audio, problems with instructors' use of the electronic white board, and the professor should encourage interaction.

Qualitative Study of Cryptography Course

One author observed the Cryptography course for 8 of 10 class sessions. We collected survey responses from the instructors and students and interviewed students and the instructors. Because each learning site had an instructor present, the dynamics of the course differed from other distant learning courses. Even though one instructor led the lectures at the local site, the other instructor interjected comments throughout the lecture, opening the dialogue between the two sites. Students at each site were interactive, by measure of the number of voicings from each site during the lecture. Students had access to an instructor at each site, of whom to ask questions. Students mentioned the benefits of having an instructor at each site numerous times.

We recorded comments, questions, and responses of local and remote students each week. Table II shows the number of comments, questions, and responses (related to course content only) voiced by the students. Typical attendance at the local site was 25 to 30 students, and typical attendance at the remote site was 15 to 20 students. Both sites contributed to the discussion. A typical class session included a review of homework solutions and a prepared PowerPoint lecture. The instructors asked for questions three to five times per lecture, but encouraged students to ask questions at any time. Normally, interaction proceeded with a student question, an instructor answer, a student question, and then an instructor answer. Three times during the term, a student answered another student's question; one of these times, the student response came from the other site.

TABLE II

NUMBER OF STUDENT VOICINGS, SEPARATED BY PHYSICAL LOCATION FOR EIGHT WEEKS OF A TEN-WEEK DISTANCE LEARNING COURSE. CO = COMMENT, QU = QUESTION, RE = RESPONSE. APPROXIMATELY 20 - 25 STUDENTS ATTENDED THE LOCAL SITE AND 15 - 20 STUDENTS ATTENDED THE REMOTE SITE EACH WEEK

Week	Local Site			Remote Site		
	CO	QU	RE	CO	QU	RE
1	0	3	4	0	8	2
2	1	3	0	0	3	2
3	5	25	5	3	17	1
4	6	17	0	0	6	0
5	4	18	7	1	9	0
7	3	15	3	4	2	0
9	3	19	9	4	21	2
10	9	10	2	0	7	2
Total	31	110	21	12	73	9

Many challenges described in the previous subsection surfaced during our study of the Cryptography course. Two major themes emerged as we studied the class and analyzed the data: 1. Instructors and students would like a more usable whiteboard since PowerPoint alone does not fit everyone's teaching and learning styles, 2. Instructors wanted more

discussions, but the low quality audio/video hindered discussion flow.

The instructors experienced difficulties in using the electronic whiteboard, and abandoned its use midway through the academic term. A remote student commented on a survey, "Professors always have difficulty with the whiteboard. I suggest looking at other whiteboard technologies, specifically ones that only respond to [the] touch of a pen, not to fingers." The instructors commented on surveys that the whiteboard was difficult to use and the ability to view the whiteboard and lecture slides simultaneously would be valuable. Some students value digression, which is more difficult when lecturing with PowerPoint slides. An interviewed student commented, "I like the discussion the most, when it goes into digression [it's] usually quite interesting, kind of breaks the monotony of lecture." Three interviewed remote students that wanted to see more diagrams, tables, and equations written on the whiteboard. In fact, one student commented that the course is challenging, since she is a visual learner and much of the material was presented in aural form. The existing technology did not support multiple learning styles, nor did it support the instructors' natural teaching style. Both would prefer to use a standard whiteboard for lecturing, but they were constrained to using lecture slides for the distance learning course.

The instructors and several students would have enjoyed a more discussion-based course. Due to the low quality audio and momentary latency, interaction was limited. One instructor wanted to discuss the politics of security, rather than keeping the course to the technical side of cryptography. An interviewed local student said, "I think [class] would be better if we could hear the questions [of the remote students]." One instructor commented that it felt like teaching "two separate classes". The two sites did not interact with each other. The small screen showing the remote students made it difficult for the instructors to see them. The instructors could not see gestures, body language, or indications of when people would like to speak. When asked how the technology affects interaction, one student responded, "The [teaching] format lends itself to watching/listening." Many students repeatedly asked for higher quality video and audio on surveys. Higher-quality audio and video could lead to more interactive discussions sought by both instructors and students.

CONFERENCEXP AND CLASSROOM PRESENTER

We took the challenges of supporting fluid discussion and flexible teaching styles as goals in developing new distance education systems

ConferenceXP is software which runs on commodity PCs and supports interaction by transmitting high-quality audio and video. It is targeted for high-bandwidth, multicast-enabled network infrastructures such as Internet2.

ConferenceXP features a custom RTP (Real-Time Transfer Protocol) implementation for low-latency transmission.

The second system, Classroom Presenter, supports real-time natural handwriting in addition to prepared lecture slides. Classroom Presenter uses a pen based computer as the instructor's input device and supports writing on top of slides as well as writing on a separate whiteboard space. All actions (writing strokes, slide transitions) are transmitted to computers displaying the presentation at the local and remote learning sites.

LESSONS FROM CLASSROOM DEPLOYMENT

We studied the use of ConferenceXP and Classroom Presenter in a Masters level database course. The local classroom was configured so that 14 students sat at tables and the remaining students in chairs around the perimeter of the room. The room featured a large rear-projection display, which covered most of one wall. The display was configured to project two side by side computer displays. The instructor taught in front of the rear-projection display. An additional projector was mounted to the ceiling and was pointed at a screen on the wall opposite the rear projection display. A video image of the remote site was projected on one half of the rear-projection screen and on the wall opposite the instructor. We enlarged the size of the projection, based upon comments made by previous instructors. Many commented that the screen was too small to allow students' faces to be seen. Other studies validate this decision since interaction is affected by the size of the remote participants [5]. The other half of the projection screen showed the lecture slides and any writing the instructor made on the tablet. The instructor wore a wireless microphone. Table-top microphones picked up local student voicings.

The remote learning site used a room equipped for large lectures. Seats were arranged in a theater style and the room accommodated approximately 200 people. Students were encouraged to sit in the center of the room (in front of the camera). Microphones hung from the ceiling, and two projection screens at the front of the room displayed lecture slides and video of the instructor. The screens were physically separated by approximately 20 feet.

The course was similar in nature to the Cryptography course. Approximately 30 students attended at the local site and 20 students attended at the remote site at the beginning of the academic term. The class met once weekly for three hours. The instructor used prepared slides to present material each week. This course was staffed by a single instructor who taught exclusively at the local site.

We studied the qualitative nature of the course through weekly surveys given to students and the instructor, interviews of volunteer students and the instructor, and observations of the class from both learning sites. We collected approximately 100 pages of written observation notes and transcribed five hours of interviews (4 hours with students and 1 hour with the instructor). The weekly surveys

asked questions to reveal students' thoughts about the interaction levels, their level of engagement with the course, their satisfaction with the audio/video, and their satisfaction with the presentation technology. Analysis of our data yielded three main lessons:

Technological Interruptions

*Interruptions in audio and video (long and short outages) had severe consequences for the learning environment (interaction, engagement, participation) at *both* sites, with more severe consequences at the remote site.*

The class experienced technology interruptions. There were multiples sources of interruptions, some causing long delays or changes in technology, and others just a short delay while the system was reset. Table III details the weeks in which the course suffered technical problems. Each outage normally required intervention by technical staff during the class. Even though some outages lasted just a few minutes, they impacted the interaction and satisfaction of the students and instructor. During week 5, several remote students groaned when they lost the video connection.

TABLE III

DETAILS OF THE TECHNICAL PROBLEMS SUFFERED DURING THE COURSE (EACH CLASS SESSION LASTED 3 HOURS). DURING WEEK 10 OF THE COURSE ALL STUDENTS ATTENDED THE LOCAL SITE FOR STUDENT PRESENTATIONS, SO THE DISTANCE EDUCATION TECHNOLOGY WAS NOT USED. THE ORIGINAL TECHNOLOGY (NETMEETING) WAS USED DURING WEEK 1.

Week	Problem	Duration
1	Lost audio and video connection (had to use telephone for audio)	2 hours
2	Audio and video not working (sent streaming video to remote site and used telephone for audio from remote site to local site)	Entire class
4	Lost whiteboard and slide projection at local site	1 minute
5	Lost connection between sites Lost video connection four times	2 minutes Each lasted 1 - 3 minutes
6	No Problems	
7	Slides and video transmission not synchronized at remote site	Entire class
8	No Problems	
9	Slides out of synchronization Lost audio from local site	3 minutes .25 minutes 1 minute
	Lost video at each site	

Technology interruptions distracted students and the instructor. Technology in a distance learning environment must run in the background. Unfortunately, during the course the technology moved to the foreground. During week 5, a local student stated on a survey, "technology still a distraction, would prefer to be in a class without it, even though I'm local." One local student celebrated the fact the technology didn't work during week 7: "today the AV to MS

did not work at all -- it was kind of nice -- no distractions with the technology constantly breaking." When the technology worked, the students noted its success. Not surprisingly, technical difficulties affected the instructor's teaching. He often stopped lecturing when connections to the remote site severed, in order give both sites the same information. During week 3 he stated in a survey, "Today it was quite disruptive and slowed me down quite a bit."

The technology affected interaction levels and engagement levels. One remote student stated that "difficulty to interact with professor generally discourages such interaction." A different remote student said of his engagement level, "I'd be more engaged if I could go to [the local site], but I can't spare the time to make the commute." A local student shows the importance of interaction in the following comment: "class was more engaging -- many people spoke up -- this helped create more ideas and helped me gel my thinking and learning." Interaction is important; unfortunately, we did not witness substantial interaction at the remote site. Table IV shows the number of student voicings (comments, questions, and responses to questions). The technical interruptions contributed to the lack of remote interaction, but even when the technology worked (weeks 6 and 8), the remote students had minimal participation. The instructor welcomed comments and questions (as seen by the high numbers of local participation), and the classroom culture allowed for interruptions instigated by students. Nevertheless, the remote students refrained from participating at equal levels on days in which the technology worked. The failed technology during earlier weeks may have contributed to their participation levels.

TABLE IV

NUMBER OF STUDENT VOICINGS IN THE DATABASES COURSE. APPROXIMATELY 25 - 30 STUDENTS ATTENDED AT THE LOCAL SITE EACH WEEK AND APPROXIMATELY 15 - 20 STUDENTS ATTENDED AT THE REMOTE SITE EACH WEEK. ADMINISTRATIVE AND LOGISTICAL QUESTIONS ARE NOT REPRESENTED BY THESE NUMBERS - ONLY COURSE CONTENT RELATED VOICINGS ARE PRESENTED. CO = COMMENT, QU = QUESTION, RE = RESPONSE.

Week	Local Site			Remote Site		
	CO	QU	RE	CO	QU	RE
1	4	22	1	1	7	0
2	13	28	15	0	1	0
3	1	35	6	1	5	0
4	5	26	28	0	1	1
5	4	26	3	0	5	0
6	8	28	22	0	0	0
7	45	28	16	0	0	0
8	9	19	28	0	4	0
9	8	16	9	0	2	0
Total	97	228	128	2	25	1

Even when the audio and video technology worked, students had trouble communicating with the other site. Student voices were difficult to hear at the other site, unless the student was close to a microphone. One interesting

comment made by a remote student is that audio quality is extremely important. This student would rather sacrifice the video to have just the audio and the slides transmitted. The video projection on the back wall of the local site helped the instructor see if students had their hands raised. However, the clarity did not allow the instructor to recognize facial gestures and other clues he relies upon when communicating with a student. He stated in an interview, "...when I see a face, I can understand the question better because I know, just sort of see the gestures and the things they do with their face shows you, the words don't always convey everything."

When designing systems to support synchronous distance learning, it is important that the technology reliably connects learning sites. It is important to provide similar experiences for both learning sites; when technology fails, the local site has access to the instructor while the remote site loses connection.

The "Distance" Feeling

Technology distraction and the physical room layout created a distant feeling at the remote site.

The remote students and the instructor felt "distant" from each other during the course. Technology distractions and the physical classroom layout contributed to the distance feeling. Local students felt "distanced" from the remote students. One local student commented in a survey, "When the line was live, I knew [the remote students] were there but...I couldn't really perceive any personalities, etc." and another said it "feels like [the] remote site [is] not there."

The remote students felt distanced in that they were hesitant to interrupt the instructor. One remote student wanted to ask questions, but he did not want to interrupt the professor, and he was not sure if the professor would see his raised hand. He stated, "say you have a question..., you have to wave or something to get his attention." A different remote student requested in-class instant messaging to ask questions of the professor. One student commented that the technology repeatedly crashes and the professor cannot hear questions from the remote site. Another student noted that most of the interaction happens at the local site, and the microphones do not always pick up the voices. The instructor needed to repeat the important comments from the discussion. The awareness levels at each site differed. The local site could see the students at the remote site, but the remote site could only see students when the view of the instructor contained students in the video image. One remote student requested another video feed of the local students.

The physical room layout at the remote site created a distant feeling. The large room had two display screens that were widely separated, making it difficult to view them simultaneously. Some students chose to sit at the back of the class in the center to improve their viewing angle while others sat outside the view of the camera in order to position themselves closer to one screen or the other. This increased the instructor's difficulty in seeing the remote students.

The instructor felt distanced from the remote students. He stated in an interview, "I never really got the [remote] students involved in the course. Even when they did talk, I didn't know who it was. ... I felt as if I wasn't in touch with part of the class." He also suggested that all remote students sit in front of the camera. The instructor often felt that only three or four people were present at the remote site, and he would have encouraged more discussion from the remote site if he knew ten to fifteen people were there. Awareness is critical for combating the distant feeling. The instructor needs to be aware of the remote students and each site needs to be aware of the other.

Presentation Flexibility

The new presentation system gave the instructor more flexibility in teaching style, and students seemed to enjoy this additional flexibility.

The instructor used Classroom Presenter to write on slides and draw diagrams on the whiteboard. The pen-based computer used during the study was not particularly sensitive to the pen input, so handwriting was a bit slow and intentional. Because the handwriting needed to be fairly large to be legible, the number of words and pictures that could be written on a single screen was limited. Nevertheless, students and the instructor liked this additional flexibility. Classroom Presenter was an improvement over the separate Smart Board, according to the students. One student commented, "Really like writing on the slides." The instructor also rated its ease of use at levels 6, 5 and 5 (out of 6 for "very easy to use") during the first three weeks of its use. One remote student found the writing to be helpful during the instructor's explanations: "[he can] write on slides so that we can see what he's saying." Interviews with local students revealed their satisfaction with the new presentation system. One student said "And then writing on the slides was extraordinarily good. You don't have to sit and look at the slides while he's writing [to keep the context]". Another student said, "I think [the writing] went quite smooth."

The instructor made use of Classroom Presenter to write text on slides, create diagrams and tables extemporaneously, draw circles and lines to create a connection between the slide material and his oratory, and create pictures, code, and text on the whiteboard. During one class session, the instructor asked students from the local site to share their answers to in-class exercises by writing on the pen based computer. Table V shows the types and frequency of markings the instructor made with the presentation system. As one can see, the instructor made use of Classroom Presenter for spontaneous writing and diagramming.

RELATED WORK

Our work complements research efforts in distance education settings, presentation systems, and videoconferencing systems. Gloster et al. studied a two-site distance education course consisting of synchronous and

asynchronous learning components [2]. They were interested in learning outcomes (end-of-course grades) while we were interested in the qualitative nature of the learning environment -- how interaction and presentations are dependent upon technology. Neal studied how technology supports interactive, seminar-style distance learning classes where students learned from personal computers [4]. Audio conference and internet relay chat supported communication, and students felt that videoconferencing was necessary to create a classroom community. Our work shows that technology must support interaction, which leads to classroom community. TELEP and Flatland are systems that support presentations and communication with students learning from personal computers [3,6]. Both technologies allow participants to communicate through text.

new technologies we addressed the challenges of ensuring high-quality audio and video and a more natural tool for writing electronically. Through qualitative analysis of the data collected, we learned of three major lessons learned. Failed technology can severely impact the interactive nature of the course. Technology and the physical room layout can further separate students. Finally, our major success in this work includes the development of Classroom Presenter, a tool that allows writing on slides and an electronic whiteboard. Instructors and students benefited from this tool.

TABLE V

MARKINGS MADE BY THE INSTRUCTOR WITH PRESENTER. THE INSTRUCTOR COULD WRITE EITHER DIRECTLY ON THE DISPLAYED SLIDE OR ON A BLANK WHITEBOARD. FREQUENCY INDICATES THE NUMBER OF TIMES THE INSTRUCTOR CREATED A MARKING IN THE ASSOCIATED CATEGORY OVER THE 8 CLASS SESSIONS USING PRESENTER.

Type of Marking	Frequency
Writing text on slide	13
Diagram/Table on slide	10
Line/arrow/circle to highlight text on slide	12
Diagram/Table/Code on whiteboard	8
Text on whiteboard	4
Student writes on slide	4
Total Markings	51

PowerPoint supports creation and presentation of lecture slides; Classroom Presenter extends this presentation software by supporting handwriting on slides. Instructors have options for pen color and navigation displayed on the tablet computer while the view displayed to the students simply shows the current slide and any annotations.

FUTURE WORK AND CONCLUSIONS

The Classroom Presenter application has evolved to address concerns that surfaced during our study. Additionally, Classroom Presenter has been used in traditional lecture learning environments. We have improved the Presenter interface (see Figure 1) and hardware. The Tablet PC offers very natural handwriting input with a stylus. The interface has also evolved to include options for pen color/type, easy navigation through slides, and a filmstrip view showing slides around the current slide. The updated Presenter system has been used in a distance education course. The instructor said of Presenter, "it made the distance stuff feel like teaching a real class instead of a canned TV show. Very nice." We will continue to evaluate and extend the features of Presenter in distance learning and traditional classrooms.

Our work contributes lessons learned while studying synchronous distance learning environments. Our work began with understanding challenges in these settings. With

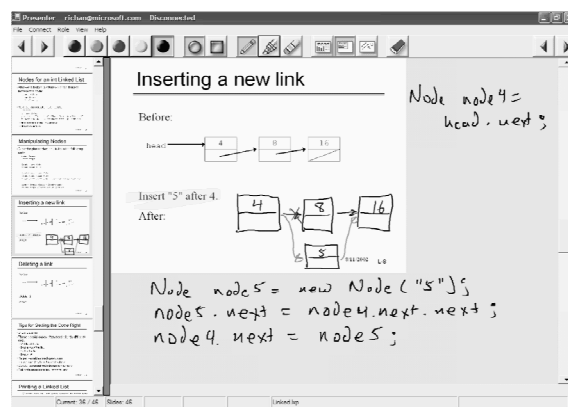


FIGURE 1

VIEW OF INSTRUCTOR INTERFACE FOR CLASSROOM PRESENTER. AN INSTRUCTOR CAN WRITE ON TOP OF SLIDES AND THE WHITEBOARD (MAIN RIGHT WINDOW), NAVIGATE THROUGH SLIDES (LEFT WINDOW), AND CHANGE PEN TYPE/COLOR (TOOLBAR). THE PROJECTED DISPLAY TO THE CLASSROOM SIMPLY SHOWS THE CONTENTS OF THE MAIN WINDOW.

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