Collaborative Technologies in International Distance Education

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Abstract

We present a case study of an international distance education course involving two sites in the US and one site in Pakistan. We use the case study to examine the elements of the distance learning environment, and specifically how those elements can be best used to promote classroom interaction. In particular we discuss the effectiveness of two software tools for distance learning that we have developed: ConferenceXP for video conferencing and Classroom Presenter to facilitate interaction across sites. We bring special attention to the use of student artifacts including digital ink and text, and their use in the presentation of design proposals, the facilitation of critiques, and in the promotion of general interaction.

Keywords: Educational technology, Collaborative design

1. Introduction

Two key objectives of design education are to expose students to multiple perspectives and to teach students to think critically [1]. In this paper, we look at a distance learning course that had these objectives, and used novel technologies to achieve them. Critical thinking was promoted by introducing student artifacts into the classroom discussion and encouraging other students to evaluate or comment on them. The course was between the US and Pakistan, which brought in multiple perspectives, and real time internet based video conferencing was used to allow communication between the participants. Through this case study we examine the questions:

1. Is it feasible to rely on internet based video conferencing for an international class?
2. Will the participants communicate with each other in a natural manner?
3. How can technology support a pedagogy that includes discussion of student artifacts?

This paper has two main contributions. One is a case study of a multisite distance course between University of Washington (UW), Microsoft and Lahore University of Management Science (LUMS) in Pakistan. The course was successful in achieving cross site interaction and bringing experiences to students that would not be available in standard courses. The second contribution is incorporating a classroom interaction system, Classroom Presenter [2] into a distance course. This allowed the students to engage in activities and have their results integrated into the classroom discussion. The standard lecture style class was enhanced by increasing student contributions and making it easier to record and critique the contributions. This was particularly important for increasing the involvement of the students at the remote sites.

Related work describing the use of synchronous collaborative environments in design education includes [3] and [4].

2. Course Structure

The course, Computing for the Developing World, examined applications of computing technologies in low resource environments. Needs assessment and critical evaluation of solutions played a central role to the course, so it had a strong design component. The course specifically addressed designing technological solutions for users in different cultures, making a multicultural perspective valuable.

The course was offered by the UW Computer Science and Engineering Department in its Professional Masters' Program. To accommodate students working full time in industry, the course was offered in the evening, once a week for three hours. Courses in the program are regularly offered as synchronous distance courses between UW and the Microsoft Campus in Redmond using ConferenceXP [6]. In this course there were approximately 25 students at the UW site, 15, at Microsoft, and up to 12 students attending at LUMS.

The inclusion of the site in Pakistan, at LUMS, came about after discussions between the instructors at UW and LUMS. It was recognized that, given the subject, an international course offering would benefit all students by presenting very different perspectives.

Verbal interaction between the sites was made possible by ConferenceXP, an internet-based video conferencing system that we co-developed with Microsoft Research [6]. ConferenceXP provides low

latency and high-quality video, which are both important in promoting verbal interaction in distance courses.

In addition to verbal interaction, a channel for students to create artifacts for class-wide discussion was provided by Classroom Presenter [2], a Tablet PC based system for classroom interaction. Classroom Presenter allowed the instructor to share slides with the students' laptops or tablets. Slides with activities could be annotated by students and submitted back to the instructor, who could then display them for discussion. For presentation, Classroom Presenter allowed the instructor to write with digital ink on electronic slides, as shown in Figure 1. The students were encouraged to install the software on their own laptops and tablets which many of them were already bringing to class. The LUMS site was equipped with a number of inexpensive drawing tablets which were connected to laptops and shared by the students. This course was the first time that the classroom interaction component had been deployed in a distance class. The use of Classroom Presenter in single classroom settings has been reported previously [5,7].

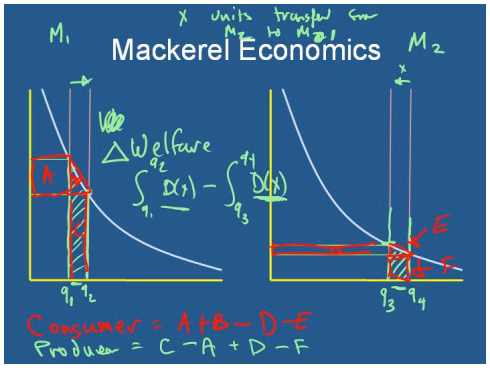

Figure 1 Classroom Presenter used to integrate digital ink and electronic slides.

3. Technology

The basic ConferenceXP technology relies on hardware-supported multicast. This has advantages and disadvantages. On the plus side, the bandwidth for multiple sites is reduced and services such as archiving can be implemented with the addition of an extra client. However, multicast is not supported across all networks, and there can be additional reliability issues. The deployment with Pakistan introduced some initial technological challenges. ConferenceXP is designed for situations where high bandwidth is available to support low latency, high-resolution video. Generally more than 4 Mb/s is used in each direction between UW and Microsoft, but with Pakistan, only about 1 Mb/s was available. This was a problem since Conference XP requires the same bandwidth connection between all sites in a single venue. Figure 2 shows the solution that we adopted. We effectively overlaid two ConferenceXP venues, allowing higher bandwidth communication between UW and Microsoft and lower bandwidth with LUMS. Audio from all three sites as well as one low bandwidth video stream from each of UW and LUMS were sent to the low bandwidth venue. Additional high bandwidth video streams were transmitted only between UW and Microsoft in the high bandwidth venue.

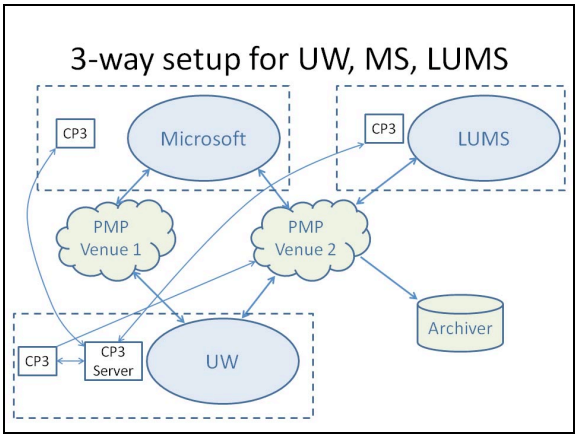

Figure 2 Schematic of deployments with separate venues for handling variable bandwidth. The archiving of the lectures was handled from the lower bandwidth venue.

On the technology side, the course was a success. For nine out of the ten classes, there were no problems with the networking – full bandwidth was available, and video quality was high. One class session was disrupted; ironically, the problem was on the UW-Microsoft link, which caused a failure between UW and Pakistan.

The latency and jitter on the Pakistan link was observed to be somewhat greater than is normally observed between UW and Microsoft. This caused slightly worse audio/video latency between Pakistan and the other two sites but was still acceptable.

Our vision for internet-based video conferencing is that it will be sufficiently inexpensive and easy to use that faculty will be able to initiate courses opportunistically, without outside expertise or significance expense. Progress is being made in that direction – but our experience with this deployment demonstrates that there is still work to do. Since the UW-Microsoft component of the course was based on existing distance learning facilities, we focus on the additional cost of adding the LUMS site. In terms of equipment, ConferenceXP is designed to run on a single, medium to high end PC. Any of the currently available multi-core processors is sufficient to support high quality video for a modest number of sites. This does not represent a major expense. The additional requirements are cameras, audio, and networking. We used a standard low cost desktop webcam for LUMS. Where higher bandwidth is available, cameras with professional-grade optics can be used to improve the experience. Audio is often the biggest challenge for

distance courses. The LUMS course initially relied on passing around a hand held microphone, which impeded audience communication. In the fourth week of the course, an echo cancelling microphone system was deployed. This worked moderately well, although on occasion there were issues with calibrating the microphone. The networking between LUMS and the other sites was not multicast enabled, so LUMS connected to a unicast/multicast bridge on the Microsoft network.

Since this was our first deployment between the sites, we did not know how robust the networking would be, so we had systems staff available on both sites before every class monitoring the networking. For the Pakistan site, this meant the engineer was needed very early in the morning to set up the course. Our goal for the future is to reduce the requirements for system support by improving the network diagnostics and adding remote management facilities.

4. Promoting Verbal Interaction

The motivation for the technology choices - high resolution, low latency audio and video - was to support natural verbal interaction between the sites. If interactivity is not necessary, there are much easier and cheaper technology options. In particular, if the audience is not going to interact with the instructor, latency does not matter so streaming video with latency upwards of several seconds, or asynchronous viewing are options. It is generally felt that round-trip latency should be less than 250 ms for real time interaction. Higher latency can be tolerated, although it will become noticeable, and is likely to impede interaction.

Appreciation of facial expressions and gestures is a significant element in natural interaction, and can be improved through the use of high bandwidth video. Typical classes between UW and Microsoft use multiple cameras and dedicated projected displays to capture, transmit and display a high level of detail. Due to bandwidth constraints, we were limited to a single video stream to LUMS, which was most often the dedicated instructor video.

In general, courses vary substantially in the level of verbal interaction. Although we do not have counts of the number of rounds of interaction in this course, verbal interactions were moderately frequent between the three sites, and the instructor was consciously promoting verbal interaction. There were a few occasions of student to student comments across the sites, although the majority of the interactions were between instructor and student.

There are two requirements for achieving an interactive distance course: technological support and the establishment of an interactive classroom environment. For the latter, the actions of the people involved are critical. The instructor must make an effort to involve the audience, by implicitly or explicitly encouraging students to contribute. The presence of a few vocal students at remote sites can also help establish a pattern of interaction. We have observed in other courses that having instructors present at the remote site can also increase the level of interaction. This course had all of these positive factors supporting interaction.

We conclude this section with several observations about the classroom interaction and the distance course:

- Facial expressions were important. For example, the UW instructor observed the LUMS instructor smile in response to a comment on software piracy, which caused the UW instructor to ask for a response which led to an interesting discussion.
- It was not always possible to tell which site a comment came from: for example, once the instructor made a reference to "the comment from Microsoft", and was corrected that the speaker was actually in Pakistan. This can be regarded as positive evidence – since there was no audible distinction between sites.
- Even though there were cameras on the audience, identifying speakers could be difficult. This was compounded by students sitting out of the camera view.
- The latency introduced by the network to and from LUMS appeared to be above the desired threshold, and the students there were observed to be somewhat hesitant to ask verbal questions for fear of causing an awkward interruption for the speaker.
- The lecture that originated from the Pakistan site received rave reviews from the US students for providing external context for the course. This lecture validated the international aspects of the course.
- Language and accents did not appear to be a problem; the Pakistani students were all fluent in English.
- Direct encouragement of comments from the remote sites was important, e.g., "Are there any questions from the students at the Microsoft site?"

In summary, the class did achieve interaction between participants of all three sites, and the goal of an international course was realized. The actions of the instructors clearly helped the level of interaction. In terms of technology and classroom setup, there is room for improvement, for example in improving the images of the remote students to make it clearer where questions are originating from.

5. Student Submissions

One of the big challenges in distance courses is engaging the remote students and giving them an opportunity to participate in the class. It is more

difficult for remote students to communicate verbally with the class, especially about ideas expressed visually, and options such as coming up to the white board to present ideas are not possible.

To address this problem, we decided to use technology that allowed student contributions to be displayed along with the instructor's slides. This allowed the instructor to pose open ended activities to students and then collect results for class-wide review and discussion.

Classroom Presenter is an application that runs on the instructor and students' machines and maintains a synchronized collection of slides. Students may annotate slides on their machine, and send them back to the instructor. The instructor can then choose to display student slides on the public display. The students' submissions are anonymous, so there is no indication from whom they come. Classroom Presenter was initially designed for the Tablet PC, although it also runs on Windows laptops with text annotation and drawing with a mouse.

The work flow for using Classroom Presenter began by having various activities embedded in the slide deck. When an activity was reached, the instructor would direct the students to work on it. Generally, students were encouraged to work in groups, so a submission would represent the work of several students. When students had completed their answers and submitted them to the instructor, the instructor would then display answers to the class, and lead a discussion about the answers. An effort was made to show a substantial number of the student submissions. Although the submissions were anonymous, students would often verbally identify their own work when it was displayed. The format of the class was a once a week lecture which lasted about three hours so the activities were welcomed to break up the lectures. A typical lecture would include about five activities.

6. Submission Pedagogy

The classroom activities are designed so that they support lecture materials, and are used to accomplish specific pedagogical goals Students are more engaged in discussion after they have spent some time working on an activity, both because they have thought about it, and because they have a position to defend. We now present three examples of activities from the class and describe how they were used. The images show the activity slides with the annotations of the students.

Solution Design – The activity in Figure 3 asked students to consider issues relevant to the design of an educational study, especially the basic research questions to be answered and the mechanics of the study. The students had to consider issues that would affect the reliability of the study's outcome, as well as the persuasive effect of the study results. In solution design activities, students typically discuss their solutions in groups before submitting. Having student designs recorded on a slide facilitates sharing and discussing designs between sites. Class-wide discussion often brings to light issues that some students have glossed over. Students often voluntarily speak up to clarify or defend the solution that they have submitted, even though the solutions themselves are anonymous.

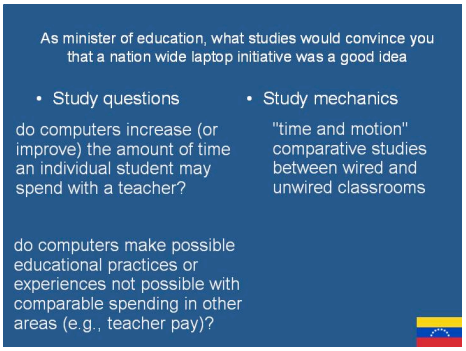

Figure 3 Solution design activity

Taking a stand - The activity in Figure 4 asked students to evaluate the use of the internet for marketing village crafts. The activity explicitly asked students to take a stand on the question, and give an argument in support of their position. Both the positive and negative positions were submitted, as well as some submissions with ambivalent answers, and some where pairs of students took opposite views. The use of student submissions is effective for this type of activity, since a record is made of different positions that have been taken, and it is easy to review the justifications for the positions.

Figure 4 Taking a stand activity

Collective brainstorming - The activity in Figure 5 asks students to describe uses of electronic pill boxes. (The devices pictured have electronics associated with them to record when they are opened.) No background on the devices was provided in advance, so the activity was to brainstorm on ideas about what could be done with an electronic pill box. This was used to collect a wide range of ideas. The class then went over the list of ideas, and identified the ones that were the most likely to be valuable.

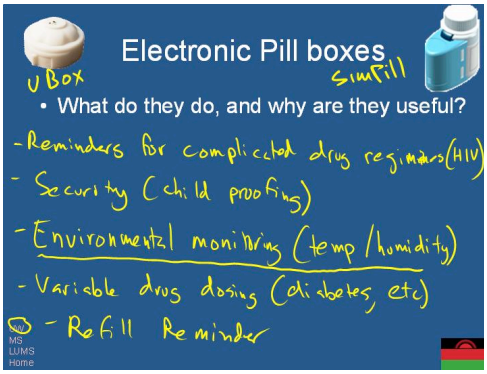

Figure 5 Collective brain-storming activity

7. Submission Evaluation

Course evaluations and students interviews gave a very positive review of the use of student submissions. The active learning pedagogy and the ability to contribute directly to the public display were both identified as positives. Typical comments from the evaluations were:

> "Classroom presenter was really effective in bringing students from remote sites together."
> "It was a great idea and I think it should be used even for classes on single sites. Because the idea of discussing the solutions on the projection is really good. We know what responses others sent and it was an amazing idea."

One student identified that the interaction model was limited, and suggested a broader communication pattern:

> "Some way of interaction between the students of remote sites should be introduced. Right now all the interaction takes place between students and the teacher. If possible, creating a social network type of thing where students can get in contact with other students during the class will be nice."

Students were asked to work together on activities, although at least one student would have preferred to work alone (but still felt it had a positive impact):

> "I felt that it was used very effectively for this class. Personally, I wasn't very fond of working through submissions with fellow students, but using it individually was fun, and I felt that seeing all the responses from other students contributed much to the class."

The use of student submissions had a substantial impact on the course. The use of activities did break up the class and maintained engagement throughout the long class periods. The instructor felt that he was able to get a much clearer idea of the students' views and had a mechanism for building the verbal discussion on student ideas as presented in the submissions. The submissions provided a persistent record of the student ideas and not just a verbal utterance to work with.

The instructor did face some challenges in working with the submissions in class. The biggest difficulty was in being able to rapidly evaluate submissions and decide how to use them in discussion. One problem was the verbosity of some student answers. A paragraph of text would often be harder to understand than a list such as in Figure 5. In addition, even though Classroom Presenter had been designed for the Tablet PC, text based submissions, as in Figure 3 were often easier to read than hand written ones.

One unanticipated case was observed in the use of student submissions. Even though the students were expected to attend at one of the main sites, the live lectures were also streamed on the internet, so it was possible for students to watch the lectures from home. In general this usage was discouraged, since it is not possible for students watching from home to participate verbally. However, a student watching from home discovered he could participate in the student submission activities, since the use of student submissions does not require strict synchronization as does verbal communication.

8. Other Challenges

There were other challenges in achieving a successful international course. A fundamental issue is finding a setting where all sites receive value through their participation, providing motivation to work toward a high quality outcome. One risk is that if the technology is not working well, the presence of a remote site may degrade the experience for other sites.

Scheduling and time zones can make course offerings difficult. In this case the twelve hour time difference meant an evening course in the US could be offered in the (early) morning in Pakistan. Daylight savings time can complicate this further, especially between the Northern and Southern hemispheres. Different school holidays meant that several of the class sessions were poorly attended on the Pakistan side. In general, alignment of academic calendars can be problematic.

9. Future Directions and Conclusions

We consider the course offering to have been successful, both in achieving an interactive international course, and in introducing a classroom technology that allowed students a mechanism for contributing their ideas to the discussion. However, there is substantial work to do to make the experience better for students, and to lower the costs for international courses.

We were fortunate in having consistent bandwidth between the US and Pakistan through a dedicated connection. However, problems can arise with international connections. For example, in our testing between UW and University of Chile in Santiago for another project, we find very good bandwidth is available, but with fairly regular episodes of high packet loss around midday. Although the quality of networks is out of our direct control, the development of better diagnostic tools associated with ConferenceXP is critical for understanding and communicating the nature of problems so that they will ultimately be fixed, thus enabling expanded deployments.

Various technological improvements might make interaction in the classroom easier. Audio is recognized as the hardest component of the system to tune properly. For classroom deployments of ConferenceXP we believe the best solution is to use hardware echo cancellation equipment. Network latency caused some problems with natural verbal interaction with LUMS. A possible enhancement to work around this problem would be to add a textual or signaling channel to the system to give the instructor a clear indication when there are remote questions. Improved video of the audience might make it easier for the instructor to interact with the system. Additional cameras, focusing on the student asking a question could also improve the interaction. We believe that improved methodology for teaching distance courses, and for promoting interaction are also important. In this particular class, language and accent were not significant problems. Additional challenges will arise when some participants are not fluent in the language the course is taught in, or if multiple languages are used simultaneously.

The use of student submissions was successful in supporting active learning, and giving students a mechanism for contributing artifacts for discussion. The anonymity of the submissions was judged by the LUMS instructor to have encouraged greater participation from that site. In a design class, the first level of review of student work can be done in discussion based on the public display. However, other forms of evaluation are often done by having students deliver individual feedback on other students work. The implementation of student submissions in Classroom Presenter does not currently support this, but it is easy to imagine extensions of the system that would provide other review options. For example, the system might allow the instructor to broadcast student work back to the students, and then have students provide additional annotations. Another approach, requiring more significant changes, would be to have student machines communicating in groups to share their designs and annotations. Classroom Presenter offers a basic model of slide based activities with annotations that has the potential to be extended to cover a richer set of scenarios in design education.

Acknowledgement

We thank Microsoft Research External Research and Programs for making this course possible through their support of the UW Center for Collaborative Technologies.

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