Chapter 9
Building Bridges:
Combining Webcasting and Videoconferencing in a Multi-Campus University Course

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ABSTRACT

Supporting lifelong learning can be challenging in that participants are often geographically distributed, have significant time constraints, and widely varied skills and preferences with regard to technology. This creates the need for designers to support flexible configurations of systems for delivering content, in ways that still allow for meaningful learning and instruction to take place. In this chapter, the authors present a case study of experience in offering a university course using a novel system that bridges videoconferencing and webcasting technologies. These have historically been separate. Webcasting scales easily to accommodate large audiences, but only supports one-way transmission of audio and video. Videoconferencing allows for two-way interaction in real time, but uses more bandwidth, and does not scale as easily. Our system allowed for increased participation in webcasts, which had benefits for both

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instructors and students. This chapter presents an analysis of interaction and awareness in distance learning contexts, and concludes with design principles suggesting that designers of future systems focus on: (1) developing novel displays and visualizations for presenting information about students, (2) reducing inequalities between modes of participation by making it clearer when, say, questions are asked by text or who is speaking when there are multiple images displayed, and (3) accommodate a range of student preferences and capabilities by supporting multiple modes of presentation.

INTRODUCTION

Lifelong learning presents many challenges to both curriculum and technology developers (de Freitas, et al., 2006). Namely, lifelong learners are different from traditional students in that they often have many career and family responsibilities, so cannot relocate or focus on education full-time. Moreover, they are often at varied life stages and have varying levels of educational background. As such, there is utility in exploring novel ways to deliver educational content to geographically distributed groups of diverse individuals.

One way to achieve this is to broaden access to existing educational opportunities to include lifelong learners who might not otherwise benefit from them. Indeed, there is considerable interest in the use of e-learning technologies to increase access to education (Serif, et al., 2009; Shea, Picket, & Li, 2005). While some universities have invested in the reshaping of existing courses and curricula for novel online learning environments (Bourne, 1998; Hazemi, Hailes, & Hailes, 2002), many have also sought to leverage existing resources by broadening access to courses already being offered on campus (Anderson, et al., 2000; Cogburn, Zhang, & Khothule, 2002; Shea, et al., 2005). Lecture-style presentations are common on university campuses (McKeachie, 2002; Bligh, 2000) and it has been said that they "serve good students well and can function as effective learning events for many" (Allert, 2004). Given that they are already being presented to large audiences, lectures are an easy opportunity to make educational content available to lifelong learners participating from home or other remote locations – the content need only be captured and streamed.

Serif et al. (2009) describe a range of strategies for delivering e-learning content to geographically distributed groups, including scenarios where small groups of participants gather in a shared physical space to join a larger remote group, as well as those where participants join in from home. The authors suggest that content can be delivered to these types of participants via webcasting and conferencing technologies, but treat these largely independent of one another.

Webcasting uses media streaming technologies to allow for live one-way audio and/or video presentations to large, geographically distributed audiences (Baecker, 2003). One-way streaming means easy scaling to accommodate very large audiences (Weinstein, 2005), and that barriers to access are low – only a PC with a dial-up modem and a web browser is required for basic performance. One drawback, however, is that most current webcasting technologies (e.g., Accordant, Adobe Connect Virtual Classroom, etc.) do not facilitate natural two-way interaction between the presenter and remote audience members during a webcast. Instead, systems treat webcasting as a one-way presentation that is distinct from a more interactive format.

In this regard, webcasting stands in contrast to videoconferencing, which allows for real-time interaction via rich media. While this is useful in facilitating interaction, multi-point conferencing requires substantial bandwidth and does not easily scale to accommodate large numbers of simultaneous remote participants using basic hardware and software (i.e., without some investment in facilities, connectivity and equipment).

This separate treatment of these two modes of delivery is artificial and potentially problematic for several reasons. First, it forces designers and educators to choose in advance whether or not the audience will be able to participate or respond to a presentation, which is a constraint rarely faced in face-to-face educational settings, even where the audience is large. Second, this choice may have important consequences in lifelong learning contexts, where audience members may have very different preferences (e.g., based on age, experience, background) about whether and how they wish to interact with the system (Chrysostomou, Chen, & Liu, 2009) and the utility of educational technology generally (Caruso & Kvavik, 2005). Third, there is substantial evidence that both learners and presenters benefit from opportunities for interaction. We argue that substantial benefits could be derived from combining these approaches to e-learning in ways that afford both interaction opportunities and configuration flexibility for designers, educators and participants.

In this chapter, we present a case study of our experience in offering a multi-campus university course using a novel prototype system that builds real-time, dynamic bridges between videoconferencing and webcasting, hereafter called the "modified ePresence" system. Our system uses webcasting to reach a broad audience, but also allows webcast viewers to periodically participate more actively via on-demand, temporary two-way videoconferencing links that immediately become a part of the streamed webcast that is visible and audible to all. We conclude with design principles and implications for designers of future systems.

BACKGROUND

As background for our case study, we discuss the principles that led to our system we describe below. We focus first on the value of interaction in systems for distributed lectures, and then to past systems intended to support awareness and interaction in lectures.

Interaction in Lectures

There has been substantial study of lecture-style presentations, and the role of interaction in these presentations. While the effectiveness of lectures depends, of course, on the individual style of the lecturer (Fardon, 2003; Saroyan & Snell, 1997), the amount of student participation and interaction also have a substantial impact (Steinert & Snell, 1999). Similarly, the amount of instructor-student interaction (Moore, 1989) can impact faculty satisfaction with online instruction (Shea, et al., 2005). These findings motivated our interest in improving interaction in lectures to distributed audiences. In particular, we focused on instructor-student interaction, as contrasted with, say, student-student interaction (Moore, 1989).

In exploring instructor-student interaction behavior, Birnholtz (2006) observed several lecturers and found frequent, though varied use of interactive techniques ranging from asking frequent questions of students to allowing students to raise their hands and ask questions. Building on this, Birnholtz et al. (2008) interviewed instructors to better understand how they interact with and respond to their students. In addition to explicit interactions such as questions, participants reported that being able to see at least some of their students' faces enabled them to gauge whether or not material was being understood, and to adjust the presentation accordingly.

All of these results served as the foundation for the system we present below. Motivated by the potential benefits to both students and instructors, we aimed to design a system that would facilitate live interaction and questions, in addition to basic instructor awareness of student presence and comprehension.

Videoconferencing Approaches to Interaction

Video has been used in distance learning for many years (see Mood, 1995, for a review). It is particularly useful in geographically distributed groups because it facilitates both voice interaction and some visual awareness of contextual information (e.g., who else is present) and nonverbal cues (e.g., gaze direction, facial expressions, raised hands) (Clark & Brennan, 1991), which are important in face-to-face classrooms, as described above, in that they allow for more natural interaction, and improve the capacity for mutual understanding (Clark, 1996).

With this in mind, Chen (2001, 2002, 2003) sought to enhance basic two-way interaction by providing augmented awareness of student and presenter gaze direction and eye contact (Chen, 2001), and of student participation patterns (Chen, 2003). While this experience highlights the importance of the awareness questions we explore, this system, like other videoconferencing systems, restricted participation by using high-bandwidth technologies and specialized sensors.

While current video technologies mean that only an ordinary Internet connection is required to participate in a basic videoconference, there are frequently quality issues with performance and reliability that can impede frequent and natural interaction (Anderson, et al., 2000). Still, there are tools such as Microsoft's Conference XP (Needham, 2006), the ISABEL project (http://isabel.dit.upm.es/), and the satellite system described by Serif et al. (2009) which can all yield good results when bandwidth and network quality are favorable.

Indeed, videoconferencing provides many benefits, but restricts participation to those with available bandwidth and other resources; and also restricts participation to the number of simultaneous participants that can be supported in a conference, which is often lower than is possible in a webcast.

Streaming and Webcasting Approaches to Interaction

A second approach to distributed lecture-style presentations is to use one-way streaming media. Isaacs et al. (1994) developed an early system to support streaming presentations, and many of the features of their system persist in what are now called webcasting technologies (Weinstein, 2005). These technologies allow for transmission of some combination of audio, video and presentation media (e.g., slides). Webcasting uses streaming technologies, which support many simultaneous users and use buffering to ensure relatively high reliability. At the same time, however, these advantages can make awareness and interaction a difficult problem.

ePresence (http://epresence.tv), an open source webcasting infrastructure, improved on basic webcasting by supporting the transmission of presentation media along with streaming video and audio, and offering two-way text interaction between the presenter and audience (Ron Baecker, 2003). We describe the modified ePresence system used in this study below.

Others have also sought to improve the speaker's awareness of remote attendees in webcasting. The TELEP system developed by Jancke et al. (2000), for example, was used to webcast live presentations on the Microsoft campus to those who did not wish to leave their offices to attend. To facilitate awareness, it allowed remote attendees to share webcam video or still images of themselves, which were displayed on the wall of the presentation space within view of the speaker and face-to-face attendees. Remote attendees could ask questions via a text chat interface.

In using TELEP, however, many remote attendees did not share video images of themselves, reportedly because many were multitasking and did not want the speaker to see that they were focusing only intermittently on the presentation. As the system was used only on the Microsoft campus, remote attendees were not physically far from the live presentation, and those who were very interested could simply walk over to the auditorium. This is critically different from the lifelong learning settings that we focus on here where attendees are more broadly dispersed and do not have this option.

STUDY DESCRIPTION AND CONTEXT

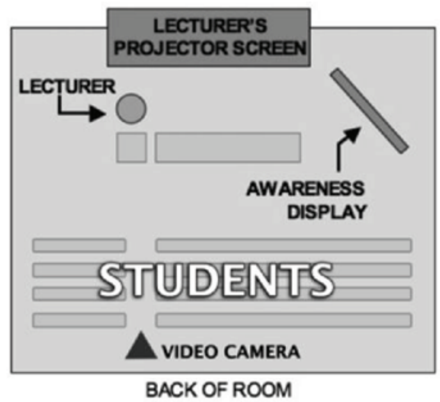
To better understand how to facilitate instructor-student interaction in presentations to distributed audiences, and to explore the potential problems inherent in combining webcasting and videoconferencing approaches, we conducted and present data from a case study simultaneously offered on two campuses of our university. Students could attend the course on either campus, or participate from any Internet-accessible location. Such flexible setups can aid in accommodating the varied needs of lifelong learners.

We sought to address questions that come from two different perspectives:

- Students:
    - How well did the system work? Were all students able to participate and grasp the content?
    - What were student perceptions of their experience? Did they feel they were able to participate? What were their reactions to the system?
- Instructors:
    - Did the system facilitate instructor awareness of students in all locations? Did the system enable instructors to interact with students at other locations?

In fall 2006, we deployed our experimental system (Figures 1-3) in an advanced Computer Science course about creating new commercial software ventures. The course was offered to students on two campuses of our university, located 25 kilometers apart (and with separate networks, both independently connected to the Internet). Approximately 60 students were enrolled at the "main" campus (where the instructor was based), and 15 at the "satellite" campus. The class met weekly for 3 hours, and consisted of lectures and discussion led by the instructor and guest speakers. Guests were entrepreneurs and professionals from software companies, who described and derived lessons from their experiences.

Figure 1. Lecture hall organized for a webcast

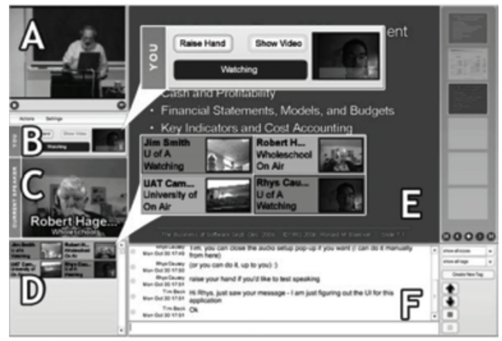


These presentations were, for the most part, delivered in a lecture hall on the main campus, though there were occasional presentations to the entire class by teaching assistants at both campuses, and two of the guest speakers delivered their presentations from remote locations using our system. Students had the option of attending the course at whichever campus was most convenient for them, or attending remotely from any Internet-accessible location. Students who elected to do this will be referred to here as "remote" students or participants, to distinguish them from the students at the "satellite" campus.

At the main campus, the lecture room was configured as shown in Figure 1. There were two video cameras, and two staff members who operated the cameras, controlled which online participants had permission to speak (i.e., were

Figure 2. The in-class awareness display, with identifying information blurred. The top right box represents the satellite campus, the top middle box is a guest observer, and the remainder are remote student participants.

Figure 3. The satellite and remote viewing interface. (a) Webcast Video, (b) User Controls, (c) Active Speaker, (d) Remote Participant List, (e) Presentation Content, (f) Chat.



part of the videoconference) and selected which of the two camera shots would be webcast.

Students at the satellite campus sat in a smaller room where the presentation was projected on a large screen at the front of the room (see Figure 2). There was also a single camera, and one staff member who was responsible for setup and camera operation. For VoIP interaction, there was a wireless handheld microphone. Students indicated their desire to speak by raising their hand, and the microphone was brought to them.

Students who could not be present at either campus could also log in and participate fully in the lecture from any location. If they had a webcam, their video could optionally be displayed on the awareness display (see Figure 3) in the lecture room.

We note that the primary instructor in this course is one of the authors of this chapter. The other authors were conscious of this potential conflict in the design and execution of the study, in that data gathering efforts focused mainly on students, guest speakers and teaching assistants, none of whom were involved with the technology development or its evaluation.

System Description

Here we provide a very basic description of our experimental system, as it was seen by our participants. For a much more detailed description, see (Baecker, et al., 2007). This chapter builds on the prior paper by providing empirical evaluation data about experience with the system described in detail in that paper.

The Viewing Interfaces

The remote viewing interface is shown in Figure 3. As with traditional webcasts, participants receive the video feed in sync with presentation material, such as slides. Questions and comments can be sent to other remote participants and the in-room display using a persistent chat tool. The chat interface is based on the BackTalk system described by Fono and Baecker (2006), and allows for tagging and formatting of messages to categorize them or attract attention, as well as browsing past conversations.

Remote and satellite students could interact with others in real time via multi-point videoconferencing between the instructor and a subset of the webcast viewers. This videoconference conversation was then streamed immediately to the remaining webcast viewers as part of the normal webcast audio/video stream.

Participation in the videoconference was facilitated using a hand raising metaphor. Participants at the satellite campus would literally raise their hands and the teaching assistant would bring the microphone to them. Remote participants clicked an icon, and were then included in the videoconference by the moderator, and granted permission to speak. Their status bar (see 'b' in Figure 3), typically gray, would then turn green and their status changed from "watching" to "on air."

The In-Room Awareness Display

The in-room awareness display (Figure 2) satisfies our goal of providing the speaker with awareness of the remote audience, and lets the speaker and local audience quickly assess the composition of the satellite and remote audiences, and their level of engagement. It consists of visual representations of remote participants, and a persistent chat window that displays text questions, comments, and contributions to discussion. Text is not intended to be the primary means of communication, but rather serves to augment voice conversation as described by McCarthy and Boyd (2005). The awareness display also indicates via color which remote participants have permission to speak via the videoconference.

Research Methods

Our study uses the case study research method (Yin, 2009). In seeking to understand our case, we used multiple data sources to gauge student and presenter response.

Questionnaires. Four questionnaires were administered to all students at periodic intervals. The first gathered baseline demographic data and student attitudes toward and experience with technology, using an established instrument by Caruso and Kvavik (2005).

The remainder assessed student experience in the course and with our system. Some questionnaire items were borrowed from course evaluation scales used at our university. Others came from established measures of presence in virtual environments (Witmer & Singer, 1998), and a small number were developed for this study. Response rates varied between 50-60%.

Interviews. Semi-structured 20-60 minute interviews were conducted with 7 students, with 4 interviewed multiple times during the term. Similar interviews were conducted with five guest speakers, and the teaching assistant at the satellite campus.

Field Observations. Field observations were conducted at both campuses. Three independent observers conducted a total of 11 1-3 hour observation sessions and recorded detailed field notes that were later typed and expanded upon for analysis. Observers paid particular attention to student experience at both of the sites and the smoothness of interaction within and between the sites. Four observation sessions were at the satellite campus, and seven at the main campus. One observer conducted observations on both campuses for comparison.

Data Analysis

Interview transcripts and typed field note documents were read and re-read several times and a preliminary coding scheme was developed. This scheme focused on themes that were important to us, but that were also clearly recurring as we read through the data. These included:

Interaction: We noted when students and presenters interacted. In particular, we paid attention to how these incidents started and ended, how smoothly they seemed to function, what media were used (e.g., text, video/audio or face-to-face), and who was involved.

Breakdowns: In looking at interactions, we were particularly cognizant of breakdowns in social process or the technical system being evaluated. For notetaking purposes, we considered breakdowns to be incidents where events did not seem to unfold as expected for at least one of the parties involved in the incident.

Attention: In observations and interviews we focused on what participants seemed to be (or said they were) visually attending to during the class. We asked them if they were paying attention to the students (for instructors) or the instructors (for students), and also noted when they appeared to be paying attention to other things. For instructors, we were particularly interested in the extent to which they paid attention to the satellite and remote students versus the local ones.

Awareness: We were also interested in the extent to which students and instructors at both sites were aware of each other. While we did look for signs of this in our observations, we relied mostly on the interview data. Here we coded instances where participants mentioned awareness of specific people or groups of people.

For the questionnaire data, we used a combination of single scale items and aggregations. Where aggregated constructs were used, they were tested for consistency using Cronbach's α, and values were above.7, within the range acceptable for social science research (Nunally, 1978).

RESULTS

In this section we describe the results from our case study. We describe student performance in the course using the modified ePresence system, student experience with the system and then discuss the experience of presenters.

Student Performance

To address whether or not the modified ePresence system had an impact on students, we first explored their performance, using final marks (unadjusted grades) in the course. We first checked to see if there was a performance difference between the two campuses. Surprisingly, there appeared to be a difference (M_{Main} = 78.37, SD_{Main} = *5.99,* $M_{Satellite}$ = 73.72, $SD_{Satellite}$ = *7.09,* t = 2.15, p <.05). We then used stepwise linear regression to see if any demographic variables, full or part time status, years of university study, years of full time information technology work experience, gender, or home campus affected students' final grades. Using this method, we found that only status (full-time or part-time) was a significant predictor ($M_{Part\text{-}Time}$= 81.10, $M_{Full\text{-}Time}$ = 75.40, t = 3.50, p < 0.01; model R^2 = 17.65, F = 9, p <.01). When these other factors are controlled for, moreover, presence at the satellite campus was not a significant predictor of student performance.

Given prior work (e.g., Caruso & Kvavik, 2005) we wondered if student experience with communication technologies in academic settings affected the perceived utility of our system and performance in the class. Students were asked to indicate their agreement with the statement "the use of information technology results in prompt feedback from instructors." Those who agreed with this statement tended to perform better in the class than those who did not, when tested using a one-way ANOVA with Tukey's multiple comparisons, and t-tests (M_{Agree} = 78.60, $M_{Disagree}$ = 69.63, SD_p = 6.13 p <.05). This suggests that students who, from past experience, perceive technology as helpful in terms of facilitating communication with and feedback from their course instructors performed better.

Next, we examined student satisfaction with the system and performance. Students at the two campuses did not differ in their satisfaction with how the system worked. Those who felt the system worked well, however, had significantly higher final marks in the course (M_{Agree} = 81.54, *SD* = 5.24; $M_{Neutral\ or\ Disagree}$ = 75.30, *SD* = 5.67, p <.05).

Finally, we wondered about student attitudes toward participation and instructor sensitivity as they related to performance. Students were asked to what extent they agreed with the statement "I participated in this class as much as I wanted to".

The mean final grade was significantly higher for students agreeing with this statement at any level (i.e., either "agree" or "strongly agree") than for those responding neutral or disagree (any level) (M_{Agree} = 81.52, *SD* = 5.77; $M_{Neutral\ or\ Disagree}$ = 75.94, *SD* = 5.46, p <.05). In addition, we found that the mean final mark was marginally significantly higher for students responding "agree" (any level) than for those responding neutral or disagree (any level) to the statement, "The instructor was sensitive to my individual needs as a student" (M_{Agree} = 80.96, *SD* = 5.54; $M_{Neutral\ or\ Disagree}$ = 75.69, *SD* = 6.22, p <.1). These results suggest that there is value to students in opportunities for them to participate and to feel supported, as those who participated and felt supported tended to perform better in the course.

Student Experience

To assess student experience with the modified ePresence system, we first looked at questionnaire data. Results (see Table 1) suggest that student experience at the satellite campus was adequate, but not equivalent to that of the students at the local campus. Students at both campuses tended to rate the course favorably, with means for both campuses above the midpoint on a 7-point Likert scale, and no statistically significant difference between them. Students at the satellite campus also tended to disagree that they would rather travel than use the ePresence system (t = 1.78, p <.1), which suggests their experience was positive. There was also a difference in students' ratings of teaching staff, which is interesting, but we cannot discern whether these reflect differences due to location or that they were assessing different people.

We must also bear in mind that it is impossible to confirm the null hypothesis – that there is no difference between the two conditions. We feel, however, that our use of existing course evaluation scale items combined with validation from our qualitative data support our claims.

Student-Instructor Interaction

We next looked for evidence of interaction between students using all three participation options – local, satellite and remote – and the instructors. Students participating in all of these ways did interact, and Table 1 shows there were no statistically significant differences between campuses in students' perceived ability to participate easily and as much as they wanted. Nonetheless, there were some issues and complications mentioned by students in interviews.

Some simply found it uncomfortable to speak into a microphone to a group of people they did not know. This satellite student, for example said:

I sometimes find it a little uncomfortable to get the microphone and talk across to the professor. We've never actually met the professor physically yet so it's unusual to a certain degree (SS2).

Table 1. Final questionnaire response results

	Local Campus (N=32)		Satellite Campus (N=8)	
	Mean	SD	Mean	SD
Course Quality	5.26	.89	4.86	1.42
Teaching Staff**	5.66	.76	4.44	1.54
Awareness	4.33	1.11	4.15	1.46
Would rather travel than use system*	3.33	1.92	2.13	3.08
Ease of Participation	4.79	1.23	4.56	1.21

Notes: All items are on a 7-point Likert Scale, where 1= Strongly Disagree and 7 = Strongly Agree. Asterisks indicate statistically significant mean differences as follows: * p <=.1; ** p <.05.

Another said:

If you ever have a nice question you should definitely ask it. I would ask it, but I'd much rather ask the professor in person than over a mic and through videoconferencing (LS1).

Another satellite campus student indicated that she regretted not being able to informally talk to the professor during breaks and after class, as local students could: "He's right there so you can ask a question right after the lecture, as opposed to us. We can't really do it unless we use email or some other form" (SS2).

At the same time, though, students in face-to-face lectures may also be anxious about speaking in front of their peers, but many do so successfully. As this student at the satellite campus indicated later in the term, he was able to adjust:

It's okay, it's not like it's unbearable. In the end, I'm getting used to it. It's just that sometimes I'm afraid my questions, like the audio voice wasn't delivered properly there, so the professor couldn't really grasp my questions…but it's not exactly a major problem (SS3).

This same student participated remotely when he was unable to attend a lecture at the satellite campus, and appreciated being able to ask the guest speaker a question: "I really like his [software] company so I got interested and I really wanted to ask questions and … I can actually ask questions even though I wasn't able to attend the lecture physically" (SS3).

Seven students signed in from remote locations during the term. We interviewed three of them, and also draw on our observations at the main campus in describing their experience. They generally reported positive experiences with remote participation. One liked the ability to ask questions via text displayed in the lecture room. In some ways, since this student expressed concern about the intelligibility of his voice questions, this was actually better than live voice interaction. Another student mentioned that she liked typing her questions because it reduced her concerns about how her accent would be understood by others, and she said it felt very comfortable: "It's just like I was on MSN or something. So it was really very familiar" (SS3).

At the same time, however, remote student experience was not universally positive. One student indicated that he missed out on informal interaction with his classmates when logged in remotely:

Often during a lecture, somebody will ask a question, or you can nudge them and ask "what did he say?" or "what did he mean?" and that's something I would have lost (LS4).

Student Awareness

By student awareness we refer to all students' ability to tell who was speaking at any given time, and who was present at the other locations. Our awareness displays were intended to provide basic awareness of these activities. Table 1 shows that there were few perceived differences between the campuses in students' ability to hear and see others who were speaking. This likely reflects that both the system and teaching style were geared primarily for presentation by a single presenter from the local site. In this regard, our data suggest that it performed well. When we break these measures down, though, some differences emerge.

First, students at the satellite campus were more likely, by a statistically significant margin, to agree with the statement that "The video image of the other site was useful" (M_{Local} = 4.16, SD = 1.73; $M_{Satellite}$ = 5.25, SD = 1.17, t = -2.13, p <.05). On the one hand, this is not surprising in that most of the content originated from the local site. It may also reflect issues with the image quality from the satellite campus, and that, as was evident in our qualitative data, the students at the two campuses generally did not know each other or want to interact.

Students we interviewed at both campuses indicated that they sat and talked with their friends from their respective campuses; and were assigned to project groups with only students from their campuses. Thus, it is possible that the video display would have been more useful to students at the local campus if they had an interest in interacting with students who were elsewhere.

There was also evidence of a separate group forming at the satellite campus. This was clear to one observer in particular, who noted that the students and teaching assistant periodically made jokes (sometimes out loud) to each other about what was happening at the main campus, knowing that the people at the main campus couldn't hear them. While students at the main campus talked to each other during class too, these were mostly whispered comments within small groups of students who knew each other well, which is distinct from the satellite campus where many comments were intended for the whole group to hear.

As for the awareness experience of those who participated remotely, they reported that they could tell who was talking when that person was on camera, but this was not always clear. One student also indicated that she felt she was able to pay closer attention and participate more fully when signed in from home. This was because:

There wasn't anybody around or anything, so I paid really good attention to what was happening in the lecture. And it was easier for me to participate because all I had to do is type, as opposed to like getting the microphone and all that stuff (SS3).

Instructor Experience

As the key goals of our system were to improve instructor-student interaction and awareness, we next examined data from our observations and interviews with guest presenters and instructors. We interviewed five guest speakers and one teaching assistant, focusing in particular on their ability to maintain awareness of and interact with the satellite and remote students.

Instructor-Student Interaction

All of the presenters we spoke with indicated that the system adequately allowed them to interact with students, and was certainly better than no interaction at all. Speakers had varying reactions, however, to the persistent chat feature of the awareness display. Some paid attention to it, noting when there were questions submitted via text. Others had to be told when these questions appeared. One indicated that it would be useful to have some sort of signal when a question appears, and to know how many other questions there are.

Despite this positive response, there was evidence in our observational data that instructors did not interact with the satellite and remote students as often as with the local students. Several speakers, for example, looked only to the local audience for questions. Another guest speaker asked during his lecture if there were any questions "from the bleachers" (meaning the satellite campus), in reference to the typically inexpensive seats far from home plate in many American baseball stadiums. While this was likely meant as a joke, it is a telling one in that it reveals his sense that the local students were privileged.

Such "local audience bias," however, was sometimes overcome via reminders. We observed several incidents where the primary instructor reminded guest speakers to ask if there were questions at the satellite campus. This helped in that the guest speakers did then look to the satellite audience, where there often were questions. None of the speakers we interviewed indicated that the explicit reminder was particularly disruptive.

There were also some incidents where the teaching assistant or a student at the satellite campus thought they were being called on by the presenter and began to speak. In actuality, the presenter had called on a local student, but this misunderstanding forced the presenter to notice that a student at the satellite campus had a question.

Instructor Awareness

All of the interviewees said they were conscious of the satellite students, but the attention paid to them varied. This is confirmed by our observations, which showed that some speakers looked at the awareness display regularly while speaking, while others did not. There appear to be several reasons for this variance.

First, several speakers and all observers noticed that the camera used primarily for capturing the speaker, and the awareness display were in different locations in the lecture room (see Figure 1). This meant that the acts of paying attention to the satellite students (i.e., looking at the awareness display to gauge their engagement with the material and see if they have questions) and giving the students the sense that they were being attended to (i.e., looking at the camera to mimic eye contact) were mutually exclusive. Some speakers were aware of this and made a conscious effort to pay attention to both the awareness display and the camera. One in particular said he had prior experience with video and made a special effort to "look into the camera … and try to say something that made them realize that I wasn't just randomly looking straight into the camera" (GS1).

Relatedly, some speakers also said they found it hard to look at the awareness display because "it wasn't on my computer screen in front of me" (GS5). This speaker looked primarily at the display in front of him and the first few rows of the audience. He felt that looking at the awareness display would have been distracting. Others said they simply were not in the habit of looking at the awareness display:

you kind of forget, you get absorbed in your material and you forget. So I don't remember consciously looking at it. I remember consciously looking at it in the beginning but not at the end (GS4).

Second, even those who did pay attention to the awareness display indicated that, generally, it did not provide adequate detail. One speaker said, for example, that she "didn't ever have a real good sense of whether they were bored or not," adding that "it was hard to see their faces, which would have made a difference, I guess" (GS2). This is in part because students at the satellite campus, despite repeated urging from the teaching assistant, tended to sit toward the back and sides of the classroom, far from the camera. While zooming in on specific students for more detail was certainly possible, this made less sense when the goal was to give the speaker an overall sense of what was taking place at the satellite campus. One presenter said, however, that he knew from the students' questions whether or not the material was getting across clearly. In other words, interaction served an awareness role as well.

In thinking about how to improve the awareness features of the modified ePresence system, several mentioned improved video resolution and more shot detail. This applied to both wide shots of the entire class, and zooming in on specific students. One speaker, for example, said that local questions were "almost [like] a one-on-one dialogue with the student asking the question…, but not at all with the remote students" (GS5). In particular, this speaker missed the ability to gauge visual reactions of remote and satellite students. Another mentioned that it would be useful to superimpose students' names, so he could use their names in calling on them.

TECHNOLOGY AND DESIGN IMPLICATIONS

We conclude with a discussion of lessons from our case study for those involved with systems for lifelong learning.

Facilitating Interaction and Awareness

As the data suggest, the modified ePresence system was effective in technically bridging the conferencing and webcast systems, and facilitating interaction. Once conversations started (either via voice or text), it was possible for participants using all three participation options to interact with the instructor. The most difficult aspect of the system, however, proved to be supporting effective instructor-student awareness. Awareness allows instructors to monitor students for comprehension, and also to tell when a satellite or remote participant had a question.

While our system did provide basic awareness, we were not successful in providing detailed awareness information about students at the satellite campus or remote participants. Our speakers were able to see that there were students there, and roughly how many there were, but wished they could see detailed facial reactions and other nonverbal cues. This is, in many ways, not surprising given that awareness is a persistent theme (and difficulty) in CSCW research (Schmidt, 2002) and the efforts that other researchers in this area have put into awareness in distributed lectures (Chen, 2001). We present two specific lessons for designers.

First is the type of entity. In bridging videoconferencing and webcasting, our design takes a very simple approach. All users, whether aggregations of individuals at the satellite campus or individuals signed in from home, are treated essentially the same, and can be viewing either the webcast or be included in the videoconference. This design decision turned out to be problematic in that, for groups, detail on the awareness display was inadequate, and individual identifying information was not provided. For individuals, their images often seemed unnecessarily large in comparison with the entire satellite campus. This suggests that, in a system that builds dynamic bridges between multiple technologies, the different usage styles of these technologies (e.g., group-group interaction for videoconferencing vs. individual-group interaction for webcasts) and different types of entities (individuals, groups, etc.) must be considered and accounted for.

Design principle 1: *Visual representations of remote participants must consider the variation in size and scope of the remote audience entities they represent.*

In its most basic form, this principle could be implemented by allowing for easy manual reconfiguration of video images of others. Given that users often do not take the time to manually reconfigure their views, however, a more nuanced approach could use face detection to gauge the number of likely people in a video view, and scale the view accordingly. These views could also be treated and displayed differently based on instructor or student preferences, and depending on how many people they contained. Serif et al. (2009), for example, describe shared room and from-home participation modes. Modes appropriate to the given setting could be pre-configured for each application.

Second, the dynamic nature of the bridges our system builds between a webcast and videoconference presents a challenge in providing awareness information. Participants in the webcast need not always (and often will not) be live participants in the voice and video conversation. This raises the question of how to best represent webcast-only (i.e., those not currently in the video and voice conversation) participants on the awareness display so that the presenter knows they are there, but they are nonetheless visually distinct from those participants who *are* in the video and voice conversation, and will be more active. Our data suggest that awareness of both of these groups is important, but scarce screen space and the need to minimize cognitive loads on the presenter make this a difficult design challenge. This challenge is addressed more fully in Birnholtz, et al. (2008).

Design Principle 2: *All participants in the webcast may be of interest to the presenter at any moment, not just those who are actively participating.*

To implement this principle, designers should consider ways to easily represent large audiences in ways that instructors can glean useful information. Lists of names, as used in prior systems, can give a sense of scope, but other forms of aggregate data about students could be useful as well. Building on work by Chen (2003), data about student attention and engagement could be displayed. To get more information about a participant the instructor could use their PC or possibly a gaze-based interface that would allow for zooming in or focusing on particular students.

Interaction and Awareness Have Different Needs

One clear theme in our results is that both students and speakers valued the capacity for interaction between sites and via multiple media (e.g., chat, audio). This was evident both in our evaluation data and in the better performance of students who felt able to easily participate. This raises an important point about the goals of our system. Our primary goal was to increase opportunities for interaction via improved instructor awareness of satellite and remote students, and via temporary two-way audio/video links. While these links did help to improve awareness somewhat (in spite of the issues identified above), their capacity for enhancing interaction was mixed.

On the one hand, the system did perform reasonably well from a technical standpoint in that participants could hear and see each other. It also allowed satellite and remote students to ask questions, which all acknowledged was beneficial and something they appreciated. At the same time, we were surprised that two of the satellite students expressed a clear preference for text interaction, because it allayed their concerns about not being understood or heard properly in the main classroom. In a sense, text was a way to overcome some of the anxieties students expressed about speaking in "public" using the microphone.

Moreover, what is also interesting here is the comfort students expressed in using text as a mode of communication. This was not just because they were confident their questions would be less likely to be misinterpreted, but because the mode of communication was similar to IM and very familiar. This was particularly the case for the student, quoted above, who indicated that asking a question was just like using MSN Messenger, a medium students use very frequently in talking socially with friends and relatives (Shiu & Lenhart, 2004). This suggests that there may be utility in reconsidering text as a mode of live participation, and that other studies of using text chat while attending to other media (e.g., Weisz, et al., 2007) may be relevant. Text also has the advantage of supporting the sort of awareness discussed by Kimmerle & Cress (2008) – that is, awareness of who is contributing and what they have contributed. In this case, the persistence of the text chat makes this information readily available.

All of this suggests that there is likely substantial utility in combining multiple media to facilitate the desired combination of awareness and interaction. Awareness is visual – it can be facilitated through video connections that involve two-way links between multiple sites. Interaction, however, is separate from video. While there may be cases (e.g., remote instructors or speakers; confident students; etc.) where interaction with satellite and remote students by video conference may be desirable, our results suggest that text also has valuable attributes.

This combination of factors raises several key implications for system design.

First is that the distinction our system draws between "watching" and being "on air" (part of the videoconference) is a technical one that is inadequate to cover the actual modes of participation. In other words, the indication of "on air" is intended to direct attention to the current speaker. The problem is that there are multiple modes of participation, such that the "on air" indicator would not indicate a text participant, for example. While it is true that the text chat display does explicitly indicate who said what, linking these indicators (e.g., "on air") to multiple modes of participation would be useful in legitimizing all modes of interaction, and in helping to maintain awareness of who is participating and how.

Design Principle 3: *Indicators of participation should take all possible participation modes into account, not just the most salient (i.e., audio/video).*

This could very easily be implemented by developing indicators that draw attention to current participants in all modes. New chat messages, for example, could cause the chat window to flash or change color, as with many instant messaging systems. Video participants who are currently speaking could also be highlighted, but this highlighting should depend on actual participation – and not just being linked into the conference or webcast stream.

Second, the utility of text raises the issue of how to facilitate text interaction such that text contributions are visible to the instructor and local students. One way to do this would be to indicate, as we discuss above, using the awareness display when people make chat contributions. Another would be to use a chat "bubble" display (as used, e.g., in comic strips) in addition to the persistent chat display and a gesture-based interface for the instructor to acknowledge chat contributions and make them go away.

Design Principle 4: *Different users may have different preferences for interaction modes, and these should be supported to the extent possible, without discriminating against text-based media in terms of ability to garner instructor attention.*

This could easily be implemented by designers, who could support multiple modes of interaction for participants whose preferences and access to technology may vary, as is common in lifelong learning contexts. Those who simply wish to watch a one-way streaming webcast at their leisure, for example, could do so. At the same time, however, those who elect to watch the webcast live could have the option to ask questions via text from home, to travel to a nearby satellite viewing site, where they could interact by video or voice without having to worry about how to configure the system, or could join by video from home, if they felt comfortable doing so. As discussed above, all of these modes of participation should also be made salient to the presenter.

Finally, we observed evidence of a cohesive subgroup at the satellite campus that talked informally, made jokes and shared the experience of watching the lecture together, in an environment where they were not audible to the instructor and others at the main campus. Instructors in future courses of this nature might seek to capitalize on this cohesiveness, by designating tasks and discussions to groups at satellite or remote locations, who can then report back to the main site. In this way, there may be value in considering the integration of online delivery of lecture-based instruction with other forms of collaborative learning, such as discussion and debate (e.g., Schwarz & Glassner, 2007).

Design Principle 5: *Instructors could capitalize on ingroup/outgroup behaviors in conferencing by allowing members of these groups to collaborate and report back to the larger group.*

Limitations

While we believe our case study makes a useful contribution, the results we present should also be interpreted with caution. We present data from a single class using a single system. It is not possible to determine whether the effects we observed may have stemmed from particular aspects of this system or aspects of the class that we did not anticipate. More research is needed to further test and validate the claims that we have made as regards their applicability to a broader range of contexts.

FUTURE RESEARCH DIRECTIONS

Our experience in offering this course also opens up many directions for future research on the best ways to foster interpersonal awareness and interaction in ways that improve student experience and performance in lifelong learning contexts. Students in these contexts frequently have significant demands on their time, may not be technologically savvy, and may have extremely varied preferences.

As such, research in the area of presentation delivery systems should focus on flexibility in configurations, and allowing for the blending of what have historically been separate modes of presentation (i.e., separating webcasting from conferencing). One key issue to explore in building these bridges is how to simultaneously and effectively facilitate speaker awareness of remote participants who are not actively speaking, as well as those who are. Our design ideas discussed above provide some initial observations about how this might be implemented, but substantial additional research is needed to further test these principles and better understand the problems at hand.

CONCLUSION

Our results from this case study of a modified version of ePresence suggest that the experience of students who participated remotely and from the satellite campus was generally positive, though not equivalent to the experience of those at the local campus. Students felt they could participate and had opportunities to interact, but also expressed some trepidation and discomfort about doing so. Instructors appreciated being able to see the non-local students and interact with them, but said the system sometimes made it difficult to maintain a sense of awareness of who was there, if there were questions, and if students were understanding the material. This suggests that designers should consider issues of awareness and interaction when making educational materials available to life-long learners via distance learning technologies. The capacity to interact was related to student performance, and instructors relied on awareness of remote participants in assessing student understanding of the material.

We presented five design principles suggesting that designers of future systems focus on: (1) developing novel displays and visualizations for presenting information about students, (2) reducing inequalities between modes of participation by making it clearer when, say, questions are asked by text or who is speaking when there are multiple videos, and (3) accommodate a range of student preferences and capabilities by supporting multiple modes of presentation.

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