Observations and Recommendations for Using Technology to Extend Interaction

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Abstract: Technology-facilitated collaboration is extending the ways in which students and instructors interact within and beyond the classroom. Our paper describes how we effectively used Personal Response Systems (PRS), lecture slides, video archives, instant messaging, and course management software to extend interaction in a junior-level Computer Science course. Besides this description, we provide our observations and recommendations to help others who wish to use similar technologies to extend interaction within their classrooms.

Introduction

A great deal of research has focused on whether technology is truly effective in promoting student learning. The initial findings of this research conclude that the use of some technologies is effective. Much of this research, however, does not give recommendations for best practices. Nor does this research offer insight into how to properly deploy technology in the classroom. Instead, this body of research tends to focus on the results of surveys to measure student reaction to the introduction of technology into the classroom, rather than its impacts on their learning. Yes, instructors continue to use a wide variety of technologies with the hope of enhancing the learning experiences of their students. The problem with the introduction of these new technologies, however, is that we do not fully understand what impact they have on the learning experience (Mayer, 2001). Does the introduction of a particular technology have a positive or negative impact? Which particular technology has more of a positive impact? Finally, what aspects of the learning experience can technology improve (Clark & Mayer, 2003)?

Collaboration is one area in which technology consistently appears to improve student learning experiences. Researchers are finding that with greater collaboration, students can become better critical thinkers and are therefore, better able to fully absorb the information they learn in class (Jonassen, Lee, Yang, & Laffey, 2005; Nelson, 2004). Instructors, therefore, are turning to computers and the Internet as a means of promoting collaboration.

A problem faced by educators who teach lecture classes at the college level is which of these technologies will promote collaboration. This decision can be divided into two important questions: (a) does technology indeed promote collaboration, and (b) what technologies need augmentation to be truly effective? These questions need to be researched more thoroughly to determine which of these technologies ultimately promote collaboration through the extension of interactivity. This paper represents a starting point in answering these questions.

Our eventual research goal is to determine whether using classroom technologies promotes collaboration. In this paper, we discuss our initial observations of testing several available technologies in a college course. Our intention is to help instructors make better decisions about which technologies to use in their classrooms.

In this paper, we describe the technologies we used while teaching a junior-level computer-networking course at the University of California, Santa Barbara. These technologies include presenting PowerPoint slides, using a Personal Response System (PRS) to respond to lecture questions, and offering a Course Management System (CMS) for off-line activities. Finally, we discuss our observations and experiences in using these technologies, and recommend how to better implement them in future course offerings.

This paper offers a taxonomy of technologies that we believe extend interaction. By understanding and organizing these types of technologies, we give instructors a better idea of what tools can and should be used in the classroom to enhance student collaboration with their peers and instructors.

This paper is organized as follows. Section 2 summarizes and discusses related research. Section 3 defines interaction and what extending interaction means. Section 4 enumerates our observations and recommendations for extending interaction. Finally, Section 5 provides concluding remarks.

Related Work

There exists a large body of work similar to ours. This body of work can be organized into two specific areas: technology studies and extensions of interaction. Technology studies refer to the use of specific technologies in the classroom, augmented with research as to their effect on the classroom experience. "Extensions of interaction" refers to research similar to ours that looks to extend the way in which we think of interaction in the classroom. While the work we discuss in each area is not meant to be exhaustive, it does give an idea of the current body of work for these specific areas.

For each of the technologies used in our work, there already exists research that demonstrates their effectiveness. For example, similar to our use of CMS to post video archives of past lectures, Lectern II proposes a system for capturing lectures that can be made available to students who are not present during the actual lecture (Joukov & Chiueh 2003). Similarly, a study done by Morgan shows the extent of Course Management Systems use by faculty along with the pedagogical gains in using such systems (Morgan 2003). Furthermore, the research on forums from Thomas looks at the effects of forums on virtual learning environments (Thomas 2002). Unlike our studies, these examples of research look at each technology in isolation, rather than examining the effects of using these technologies in conjunction with each other.

The work done by Creed is very similar to our research (Creed 1996). Creed shares his experiences of using technology in a junior-level psychology course and provides many insights and suggestions for further study. His suggestions, however, focus more on the pedagogical issues of integrating technology into his teaching than the technical issues as well. Also, the main technology discussed is the use of e-mail for student communication. Our work goes beyond the use of e-mail and uses more recent technologies to extend interaction. Ciolfi (Ciolfi 2004) and Roschelle (Roschelle 2003) conduct similar research, though they too focus more on the pedagogical implications than the technical implementation.

Extending Interaction

This section gives a working definition of interaction and then lists and categorizes examples of possible ways students can interact with their instructors as well as the course material.

Defining Interaction

For this paper, interaction is "the interplay or reciprocal action" between students, instructors, and the course material (Oxford 2005). This broad definition of interaction includes all the ways that information is communicated in a classroom setting. For example, the traditional lecture is not, strictly speaking, an interaction since the communication tends to emanate from the instructor to the student. This example is a one-way communication channel, and the goal of our research is to add additional communication channels between students and instructors, as well as student to student, and student to subject matter, thereby creating a truly interactive classroom.

For the purposes of organization, we divide interaction into two main classes: *asynchronous* and *synchronous*. For example, lecture sessions are synchronous when participants can expect immediate responses from each other. Asynchronous interaction, such as through e-mail, occurs when the participants are not necessarily expecting an immediate reply. Asynchronous interaction, therefore, means that interactions may take place at different times.

Evolution of Interaction in the Classroom

From the classroom's inception, it has been an instrument of interaction. Rather than merely allowing a student to read and absorb information from a book, or other forms of writing, the classroom is where students can see the subject matter come alive and be presented in new and interesting ways. These new ways of interacting with the material allow students to better assimilate the information in their minds. Furthermore, students can give feedback to an instructor in the form of questions, and instructors can test students through examinations. The modes for communicating this feedback, however, have not remained static over time, and have evolved as new technologies and new techniques have developed.

Traditional interaction between students and instructors has mostly consisted of in person, one-on-one, or in-class discussions of the material. Examples of these interactions are lectures and private meetings with the instructor. This type of interaction still occurs today, but is enhanced using technology to increase the opportunities for these interactions to occur. These same techniques for interaction also apply in student-to-student interaction. Finally, interaction with subject matter has traditionally come in the form of written material. While some disciplines consider reading to be a form of interaction, given our definition, we do not consider it so because there is no two-way communication. However, we still discuss it here because of the impact that technology has had on obtaining these written materials.

In this century and the last, technology has greatly enhanced the ways in which interaction takes place in academic environments. The invention of the telephone and other forms of mass communication, generally, has allowed more opportunities for students and instructors to interact. While telephones have provided more opportunities for interaction, other forms of communication have also impacted the way students learn. Television and the Internet, specifically e-mail, are two major technological advances currently used in the classroom as tools for interaction. However, Cuban (1986) has shown that educational technologies of the twentieth century, such as motion pictures, radio, TV, and computer-based programmed instruction, generally have not lived up to their potential.

The invention and eventual inclusion of television in the classroom have greatly increased the opportunities for interaction. Television frees students from the restrictions of time and place for interaction. Students can watch lectures asynchronously on a different continent, at a different time, even many years after the actual lecture. With the addition of two-way teleconferencing, television becomes a truly interactive tool for the classroom. Teleconferencing, an extension of basic television technology, allows students to be in a geographically different place than the lecture, but still allows students to ask questions, thus meeting the criteria for true interaction.

More recently, the introduction of the Internet into the classroom has provided the greatest increase in opportunities for interaction, both synchronously and asynchronously. E-mail is quickly replacing letters and telephone calls as a means for interacting with an instructor. This same effect is seen between students as well.

These advancements in technology have led to the current state-of-the-art in education, consisting of lectures enhanced by PowerPoint slides and non-lecture interaction enhanced by e-mail. In addition, the digitally recorded materials that can be viewed after a lecture have added to the lecture experience. While these technologies represent the current state-of-the-art, newer technologies are being developed that may soon replace them.

The Internet and high availability of connectivity on campuses have made more recent interactive technologies possible. These interactive technologies include everything from Personal Response Systems (PRS) to the simple archiving of lecture material. Personal response systems are devices that allow students to respond to questions en masse rather than through the traditional method of selecting one student to answer. These response systems can be anything from colored blocks to infrared devices, or even radio wave devices. These types of systems mimic the Delphi Technique, and are best described by the ask-the-audience portion of the television show "Who Wants to be a Millionaire" (Linstone & Turoff 1975). Lecture material archives usually come in the form of providing lecture slides or notes as well as digital recording of the lectures themselves.

Other examples include Course Management Systems (CMS), and synchronous and asynchronous messaging. Course management systems allow the automatic creation of course web sites through a common program. This type of system allows students to use a common interface across all classes and can also be used to disseminate and collect course materials throughout the life a particular course. Many different types of systems have already been

created and studied. An example of synchronous messaging is Instant Messaging (IM) where both participants are logged on and communicating simultaneously. An example of asynchronous messaging, besides e-mail, is web forums or message boards. Here, participants are not expected to be on the forum simultaneously and correspondence may take place with a large gap in time, much like letter writing.

Specific Examples of Extending Interaction

Listed below are several examples of the technologies we deployed in an effort to extend interaction. We used these technologies in a junior-level networking course at the University of California, Santa Barbara. Dr. Kevin Almeroth taught this course, with the assistance of his graduate students, Hangjin Zhang and Allan Knight. We presented this course over 10 weeks during the spring quarter of the 2005 academic year.

Personal Response Systems

Personal Response Systems (PRS), generally, give immediate feedback to an instructor by asking all students to answer a question from a menu of possible choices. Such systems have existed for many years and may include computer technology or rely on innovative, non-technical solutions. For example, over 20 years ago, colored cubes were used to allow students to respond to a question given a menu of answers. The instructor could then gain immediate feedback from the students about how well they understood the material. Because of the lack of computer equipment during at the time, computer-based personal response systems were not feasible. While this system provided an innovative method for responding to an instructor's query, instructors could not record the exact count of both correct and incorrect responses from students. The use of a computer-based PRS, however, does allow the collection of more detailed data.

Uses of personal response systems goes beyond simple question and answer sessions. A PRS may also be used to take attendance or monitor the engagement of students with the current material. Attendance may either be actively taken, as a separate question, or implicitly taken based on the students who responded to questions during the lecture session. Also, students can give periodic feedback to the instructor about how engaged or interested they are in a particular set of material.

Today, many choices for a PRS are available for use in the classroom. A state-of-the-art PRS uses either infrared (IR) or radio wave (RW) technology to collect student responses. The IR systems use technology similar to those used for television remote controls. An IR sensor is connected to a computer and each individual student receives a personal response device, or a "clicker," with a unique identifier. Each response is then read by the receiver and recorded on the computer attached to the sensor. The drawback to using IR technology is that (a) communication is one-way, therefore, students must see an indication of their answer on the sensor machine, and (b) IR technology allows only one response to be read at a time, meaning students are forced to click their answer several times before having it recorded. While these drawbacks are usually bearable in smaller class sizes, anything over 30 students makes such systems nearly impossible to use.

An RW-based PRS, however, overcomes many drawbacks of an IR-based PRS. While these systems are very similar to their IR cousins, they do not suffer from the same drawbacks. An RW-based PRS allows two-way communication meaning that an acknowledgement of the student response is returned to the student clicker. Also, managing communication of a greater number of students is possible. Because these systems tend to be more expensive, they may not be suitable for classes smaller than 30 students. An RW-based PRS, however, is suitable for larger classes.

For our work, we used the Interwrite PRS (GTCO Calcomp 2005). There were several reasons for this choice. The first reason was the low cost of Interwrite's solution. Their sensors cost approximately $100 and each clicker costs about $20. Therefore, the expected price for a class of 30 students is about $700. We loaned each student a clicker and recorded the number for each. In this way, student information could be entered in the accompanying software and each clicker then associated with a particular student.

To perform a question and answer session, a plug-in for Microsoft's PowerPoint presentation software was used to create a presentation slide with a question. With this question, we displayed a menu of answer choices. Once the instructor asked the question, the students were given a fixed amount of time to answer. During this time period, students were allowed to change their answers up to three times. Each of these answer changes, however, was

recorded. Once the time period ended, students saw the results of the question. The plug-in showed a histogram of responses to each answer choice. This slide also highlighted the correct answer. Based on the performance of the students, the instructor can modify the lecture if, for example, further clarification is needed for the current subject matter.

Course Management Systems

A course management system (CMS) can be used to handle many aspects of a course. First, it provides the students with a consistent interface to course material that goes beyond a simple Internet page. Second, it offers students with up-to-date information about the course. And finally, a CMS allows more interaction with the instructor and fellow students. This interaction usually falls under the classification of asynchronous communication, however, synchronous communications may be possible if live chats are integrated into the CMS.

In reality, a CMS is merely a collection of tools that allow students and instructors to interact using the Internet and a web browser. Examples of tools that a CMS system may provide are grade books, assignments, on-line evaluations, forums, and of course, a means for disseminating lecture materials. Also of great importance is a mechanism for authentication. These mechanisms are important for to protecting student the privacy of the students. Authentication may come from different sources. There may already exist a centralized authentication system on a campus, or the CMS itself may provide authentication.

For our work, we chose Moodle because of its open-source licensing (Moodle 2005). This licensing scheme offered several advantages. First, Moodle is free and, therefore, fundamentally very affordable. Second, because Moodle uses the General Public License (GPL, version 2), we can modify the code to meet our needs and redistribute the modifications to others who may find our modifications useful (Free Software Foundation 1991). Another strength o of Moodle is that it is designed to support the social constructivist model of learning, which assumes that student learning can be enriched through social interaction. This social constructivist model fits with our goal of promoting collaboration and extending interactivity. Therefore, we deemed Moodle the best fit for our needs.

The Moodle website, as created for our test course, provided the students with several tools for use throughout the course. First, we used it to disseminate and collect materials such as homework assignments, lecture materials, and links to information pertaining to the class. Second, it provided the students with a centralized calendar of events for everything from exams to homework due dates. Third, forums were created to allow students to ask questions of each other, the instructors, and the teaching assistants. Fourth, students could follow their progress through an on-line grade book. Finally, live chats were created for question and answer sessions similar to office hours.

Synchronous Messaging

Synchronous messaging comes in many forms: Short Messaging System (SMS), instant messaging, and group chats, for example. Any of these synchronous messaging systems are suitable as an instructional aid. In most applications, instant messaging and group chats provide the needed functionality. By allowing students to talk to each other and their instructors one-to-one or one-to-many, instructors can greatly increase collaboration, and therefore, help to extend interaction. As a recent poll found, more and more students are saying e-mail is antiquated, much as their predecessors viewed the old-fashioned “snail mail” (Lenhart et al. 2005). And we are now on the cusp of these students entering universities. Data we have collected for our research, as yet unpublished, suggests that a higher percentage of freshmen and sophomores in general education courses regularly use instant messaging than do students in our junior-level networking course in the Computer Science Department.

For our course, we used AIM instant messaging for virtual office hours to conduct one-to-one sessions with students. We also scheduled regular chats using the provided Moodle plug-in for informal question and answer sessions. The logs for these interactions were kept for later analysis.

Asynchronous Messaging

Asynchronous messaging usually comes in the form of forums, bulletin boards, mailing lists, or news groups. Each response starts a new thread, and its length is measured as the number of related responses.

For our course, we again used a plug-in supplied with Moodle. The default course setup contains two forums, one for the class, and one for the private use of instructors and their assistants. The basic concept is the same as most forum systems. Users can login, then leave questions, comments, or responses to previous posts. While this tool may be especially useful for programming classes with large programming projects, getting students to post their questions to a forum can take some creative coercion because most students prefer using either e-mail or instant messaging for asking simple questions.

Lecture Material Archiving

Providing lecture materials for viewing may not initially seem like an interactive process. Archived lecture materials do, however, facilitate other extensions of interactivity. Allowing students to review missed lectures or lectures not initially understood may lead to questions or interaction that may not have otherwise taken place.

For our course, we digitally recorded each lecture session. We made each of these lectures available on-line through the CMS for students to download. We recorded when and who downloaded each lecture recording by placing links to these materials in the CMS, creating a means by which to evaluate the usefulness of providing the material.

The data we collected shows anecdotal evidence that providing lecture video is valuable to the students. These data suggest that (a) students are using the videos, and (b) the students are using them for study purposes. For example, the data shows that of the 36 students enrolled in the class 33 of them (92%) downloaded a lecture video at least once. Furthermore, only 4 of the students downloaded only one video. In fact, the median number of downloads was 6 lectures. Also, the data suggest that these videos were being used to study for examinations. Of the 288 downloads, 223 (77.4%) occurred during the week leading up to the midterm and final examinations. Table 1 provides more details about the data associated with the lecture videos.

Total Videos	18	**Videos Viewed**	18
Total Students	36	**Students Viewed Videos**	33
Total Downloads	288	**Max Download for Single Student**	51
Downloads Week Prior to Mid-term	104	**Downloads Week Prior to Final**	119

Table 1. Lecture Video Statistics

Observations and Recommendations for Extending Interaction

Having used the above set of technologies to extend interaction for several classes, we developed a list of observations and recommendations about each of them. Eventually, we hope to do empirical research on these technologies to gain a deeper understanding of their impact on the classroom experience. For now, however, we provide the following observations and recommendations for the technologies we used.

Observations

1. **PRS question limit**. We found that, generally, asking the students only one or two questions per lecture session is feasible. This number may increase with the use of RW-based response systems, but the value of asking more, or even many questions, is still an open question.
2. **PRS preparation time**. Our temporary classroom setup had to be dismantled after each lecture session. Unfortunately, redeploying our setup before each class sometimes forced us to delay the start of class. This kind of problem needs to be fixed, or else the technology serves as a significant distraction.
3. **Assignment backup with a CMS.** An unforeseen advantage to using web submission of assignments is the creation of backup copies of assignments. When students submit their assignments, these submissions can be used for backup purposes if the student loses, destroys, or alters a later version.
4. **Response to using a CMS.** Students seemed to respond positively to and enjoyed using a properly designed course website as an enhancement to the classroom experience. Instructors also find such systems very useful. Moodle is a great time saver when used as a means of distributing assignments and collecting them.

5. **Availability through IM.** Synchronous messaging, especially as instant messaging, is a great way to be more available to students. The feedback we have seen from the students, so far, seems to indicate they appreciate having more access to the instructors and their assistants.
6. **IM Logs are useful.** IM logs contain questions that many other students may also have, but have not asked. Taking these questions and posting them on the course website may help other students who would not otherwise ask the question.
7. **Students' willingness to post to forums.** Our experience shows that unless the forum offers the students value, other than an answer to a question, they will ask their questions via e-mail, instant messaging, or in person.
8. **Student use of lecture material.** In our experience, students will take advantage of lecture materials, such as lecture notes, and video archives offered for download.
9. **Institutional adoption**. We have observed several instances where our own institution was considering wider adoptions of technologies similar to the ones we used. While these instances are a good sign that universities are taking new technologies seriously, it can also mean the institution is adopting a similar, competing technology, which can result in instructors and students having to adapt to multiple systems.

Recommendations

1. **Use RW-based response systems.** IR-based systems work for smaller classrooms; the necessity for feedback on the presentation screen causes much delay and does not scale very well.
2. **Install PRS permanently.** Having a permanent setup saves much time.
3. **Use the same CMS across the institution.** We feel strongly in providing the students with consistent tools in the classroom throughout the university to provide conveniences for students and instructors
4. **Create a special IM account.** Class-specific accounts for class-based IM sessions should be used to separate private IM accounts from class-related accounts. This separation provides a measure of privacy for personal communication and allows class-based availability to be independent of private availability.
5. **Limit IM availability.** We have observed that students expect an answer whenever an instructor is logged into an IM account. Therefore, if an instructor does not want to be available to answer questions, he or she should log out. Otherwise, students lose faith in the system.
6. **Offer incentives for using forums.** We recommend offering students incentives, such as assignments that require forum posts, or participation credit, for using the forum; otherwise, these forums may go unused.
7. **Create a policy for downloading lecture material.** Students may come to rely on lecture materials being available online and skip coming to lecture entirely. There are two approaches to solve this problem. The first approach is to warn students of the pitfalls and then let them make their own decision. The second approach is to use the other systems in the class, such as the PRS and CMS, to identify those students who do not attend class and advise them to do otherwise. Perhaps the best solution is a hybrid of these two approaches.
8. **Determine if your institution is using or plans to use similar technologies.** As stated in our observations, we have seen several instances where our university was using a competing technology that was similar to the ones we chose. We recommend that before adopting a new technology, find out what your institution is using, and use the same, if possible.

Conclusions

In this paper, we have organized and outlined the use of several technologies for extending interaction within the context of a traditional course. While this paper offers no definitive conclusions as to the effectiveness of these technologies, we have given our recommendations for what systems work and which technologies have a greater impact on the learning experience. Our recommendation is that, as educators we continue to push the envelope and use technologies to our advantage. These technologies can help to extend interaction within and beyond the classroom, thus increasing opportunities for collaboration. However, as we continue to explore the uses of technology in the classroom, we should also assess and determine which technologies we should continue to use and which we should discontinue. Our paper contributes to this overall conversation and our future work will look to bring a more definitive answer to the question of how technologies can be used to extend interaction, and therefore enhance the classroom experience, for students and instructors (Mayer, et. al., 2006).

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