A Distance Education Course in Computer Engineering at NC State University

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Abstract

This paper discusses lessons learned from a distance education experiment between the University of North Carolina at Asheville (UNC-A) and NC State University (NCSU). NCSU is located in the eastern portion of North Carolina, approximately 250 miles from UNC-A. A sophomore level core course in both Electrical & Computer Engineering curricula was taught using a completely synchronous delivery mechanism on a traditional closed circuit television network during the first semester of the experiment. An Internet-based, asynchronous delivery mechanism was included during the subsequent semester. This paper provides details of the methods used at NCSU, along with a presentation of the advantages and disadvantages of each delivery mechanism. A major point of the paper is that when we considered the issue of student learning, there was no statistical difference in performance between the students at the remote location and the students at NC State University.

Introduction

The rapid advances in technology significantly enhance the quality of life and productivity in our society. However, the utilization of this technology results in additional costs to educational institutions and private industry. Specifically, engineering graduates must continually retrain themselves or they will find their skills obsolete in a much smaller timespan than was true for their predecessors. At the same time, industry continues to place a tremendous burden on engineers to improve productivity in order for them to compete in the global marketplace. Hence, traditional engineering education must change significantly to address these continuously changing factors.

Over the past few years, universities have begun to significantly change their method of course delivery. Today, faculty can deliver

courses using new technology rather than using the traditional lecture approach. Distance education uses this technology to provide educational opportunities to a potentially broader range of students. Many of these students hold full-time positions as engineering professionals in private industry. They participate in distance education courses that range from videotape based courses (Morse 1998, Petre 1998) to two-way audio-visual courses (Kashy 1996, Graham 1998).

Most distance education courses can be classified into one of three categories: synchronous, asynchronous, or a combination of the two (Boulet and Boudreault 1998). *Synchronous distance education courses* are closely related to traditional lecture-based courses since they *require that both the student and the instructor have a regularly scheduled meeting time and place*. This requires the introduction of an extended classroom wherein students are not required to travel to the university campus to participate in a class. Non-traditional students can meet at one or more remote classrooms that are linked to the instructor's classroom using some sort of network. Examples of synchronous distance education courses include: courses delivered via closed-circuit television networks or courses delivered using a public or private television network. *Asynchronous distance education courses do not require students and the instructor to meet at a scheduled time and place*. In this case, students can participate in the classroom at times that are convenient to the student. Examples of asynchronous distance education courses include: videotaped courses, correspondence courses, and courses offered via the Internet. In the context of this paper, hybrid distance education courses contain both a synchronous component and an asynchronous component.

Synchronous distance education courses have an advantage over other distance education courses where students are dependent on instructor interaction. In these courses, students can interact with the instructor obtaining feedback almost instantaneously. Students can also interact with classmates while participating in collaborative learning sessions like brainstorming. A course that requires students to complete projects using design software is a good example of a course that requires considerably more interaction with the instructor and fellow classmates.

Synchronous distance education courses can cause scheduling problems for non-traditional students. These students have a hectic schedule since they often hold a full-time job or have several

children. Scheduling an examination for a typical course in a university containing a moderate number students can become a major problem, so scheduling a time for a distance education class to meet is more difficult. Also, students participating in synchronous distance education courses cannot learn course topics at their own pace.

Asynchronous distance education courses remove the scheduling problems for non-traditional students (Swaford et. al. 1996). Students can access course materials at any time that is convenient for them. In this type of distance education course, students can learn at their own pace and can potentially finish a course in much less time than the traditional semester/quarter course. However, there are many drawbacks to asynchronous distance education courses (Thoennessen et. al. 1996, Lewis et. al. 1991). A major disadvantage is the fact that students have limited interaction with the instructor. For typical asynchronous distance education courses, the students may meet only a few times per semester to take major examinations. For some courses, this lack of interaction can create problems with student learning. Students that are being introduced to basic course concepts for the first time initially need significant guidance and assistance from the instructor. As the course progresses, these students become less dependent on the instructor as they improve their understanding of course concepts. Also, students participating in asynchronous courses tend to have less inter-action with other students in the course.

This paper is written for the potential user of distance education technology, both synchronous and asynchronous, to facilitate planning and implementation. Next, we present the advantages and disadvantages of using this technology from a perspective that addresses its impact on learning. Note that when we considered the issue of student learning, there was no statistical difference in performance between the students at the remote location and students at NC State University.

ECE 212: Fundamentals of Logic Design

ECE 212 is a core course taught in the Department of Electrical & Computer Engineering at NC State University. It is a required course for both electrical and computer engineering majors that introduces students to the fundamentals of digital logic design. Since all engineering students take a common curriculum during the freshman year, this is typically the average student's first course in the department. ECE 212 is taught as a part of the Two Plus Two program in the College of Engineering at NC State University. Students enrolled in this program take general courses in math, science, and humanities during their first

two years at the University of Asheville. They also take a few introductory engineering courses that are offered as distance education courses. During the final two years of the program, students take the remainder of their major engineering courses while attending at NC State University. The final engineering degree is awarded by NC State University. The course description for ECE 212 follows:

ECE 212 - Fundamentals of Logic Design. Introduction to digital logic design: Boolean algebra, switching functions, Karnaugh maps, modular combinational logic, flip-flops, latches, synchronous sequential circuits, case studies asynchronous digital design.

A challenging feature of this course is that students complete the design of a digital system of modest complexity as a class project. Student teams are required to use computer-aided design tools to verify design functionality prior to building the system in the associated course laboratory. Typical class projects include: a digital simon game, a home security system, an elevator controller for a building with 4 floors, and a digital dice game.

The Traditional Distance Education Course

During the Fall semester of 1996, approximately 60 students took ECE 212 (Fundamentals of Logic Design) at NCSU while three students took the course via closed circuit television at UNC-A. While this was a traditional distance education course, there were a variety of features of the course that distinguished it from typical engineering courses and made the course a prime candidate for our experiment.

The course was broadcast via the NC-REN closed circuit television network from a studio at NC State. Students at NC State and UNC-A used voice-activated camera switching systems providing two way audio and video. The instructor used an overhead camera to display previously prepared notes and to zoom in on parts of the lecture notes for increased emphasis. Also, a personal computer, connected to the university computing network, is available in the studio. All images on the screen of the PC can be displayed for local and remote students. Hence, lecture notes contained in electronic presentations were utilized.

The instructor published the course materials on the Internet at the course web-site so that they would not have to be handed out or mailed to NC State and UNC-A students, respectively. This web-site includes many example problems that were similar to the problems presented in the lecture and in homework assignments. In fact, these example problems were actual homework assignments from previous semesters. Both the homework assignments and the solutions are accessible via the course web-site.

Figure 1 shows the ECE 212 web-site that was used for the course. The

web-site included examinations, important notices and announcements, examination and homework due dates, the course syllabus, the lecture schedule, and other vital course information. Tutorials on computer-aided-design (CAD) tools used in the course could also be read and/or printed from the web-site. Software that students could download to a personal computer to perform digital logic design and simulation, along with course notes developed by the author of the textbook used in the course, was available via the course web-site.

Even the regular sessions of the ECE 212 course, prior to the Fall 1997, took advantage of current technology. This course was one of the first in the department to utilize the concept of "*course lockers*", or shared file systems, that could be accessed by the instructor, teaching assistants, and the students. Student projects for each student team were accessible by all team members. Instructors and teaching assistants evaluated student projects on-line, avoiding the need to schedule individual time slots for project evaluation. All course materials that could be accessed via the course web-site were also available via the course locker. Also, CAD tools and other restricted software for use by students enrolled in the course were accessed from the course locker.

Office hours for the UNC-A students were held via the Internet using the Multicast Broadcasting on the Internet (MBONE) software. The MBONE tools provide two way audio/video communication between
the instructor and the remote students. Attached to each workstation is a small camera and microphone connected via dedicated audio/video processing card. A pressure-sensitive tablet is also used with the MBONE whiteboard (*wb*) tool to simulate the use of a notepad or chalkboard. These office hours were held for both local and remote students simultaneously. The whiteboard was very useful since a Postscript™ version of an example problem could be imported and viewed by the instructor and students participating in office hours. The pressure-sensitive pad with pen is used to make annotations on example problems and to allow students to answer questions posed by the instructor.

Figure 1: The ECE 212 Web Site

ECE 212 on the Internet

During the Fall semester of 1997, approximately 20 students took the course at NC State while five students took the course at UNC-Asheville. This course was taught using both the synchronous and asynchronous course delivery mechanisms. The synchronous lectures were taught via the Internet using the MBONE software. The class was broadcast from a special distance education classroom located at NC State. Asynchronous lectures via the Internet were also provided during the Fall semester of 1997.

The synchronous lectures were broadcast via the Internet using the MBONE software tools. Prior to the use of the MBONE tools for the synchronous lectures in ECE 212, a number of commercial tools, both Internet and ISDN-based, were evaluated. It was found, for the purposes of delivering synchronous distance education courses, that the MBONE applications suite was most satisfactory. The tools used extensively in ECE 212 include: *sdr* (session directory manager), *vic* (the video conferencing tool), *vat* (the visual audio tool), *wb*

(shared whiteboard), and *wbimport* (the whiteboard import tool).

An electronic whiteboard measuring approximately 4' x 6' was interfaced to a Unix workstation in the distance education classroom at NC State. The large whiteboard is pressure-sensitive, similar to the tablet used for on-line office hours. While students at NC State could view the whiteboard like any other chalkboard, all notes written on the whiteboard appeared on the screen of the workstation and was broadcast to students at UNC-A. The *wb* program was used to augment notes written on the large chalkboard. Information could be typed into the whiteboard program and/or PostScript™ files with diagrams of sample digital circuits. Large monitors located around the distance education classroom at NC State allowed local students to view the screen of the computer workstation containing the combination of handwritten and computer annotated lecture notes.

Figure 2 shows a typical brainstorming session held during class from the UNC-A distance education classroom. In typical brainstorming activities, a small design problem is presented. Student teams are required to solve the design problem during class time while the instructor provides assistance to individual teams. Note that a Unix workstation was used to receive data sent from the electronic whiteboard at NC State to the remote students at UNC-A. A projection system displays the contents of the whiteboard on a screen located in the front of the classroom. A retired engineer served as a teaching assistant for the remote students to facilitate learning/brainstorming in the experimental environment.

The asynchronous lectures were provided via the course web-site. Presentations developed using a PC-based software tool (PowerPoint™) were augmented with audio and placed on the world wide web. Students are able to click on an audio button icon to hear the instructor giving a short lecture. Several synchronous class periods were skipped to allow students to evaluate the asynchronous lectures for educational content and ease of use. Originally, it was determined that one lecture would be synchronous and the other lecture would be asynchronous during each week of the class.

The course web-site and course lockers were also used during this semester to alleviate the need for handouts and to provide vital course information to students at both the local and remote sites. The students at UNC-A could access NC State's Eos computing environment and view exactly the same environment as the NC students. Supplemental information was also added to the web-site for students to read and study.

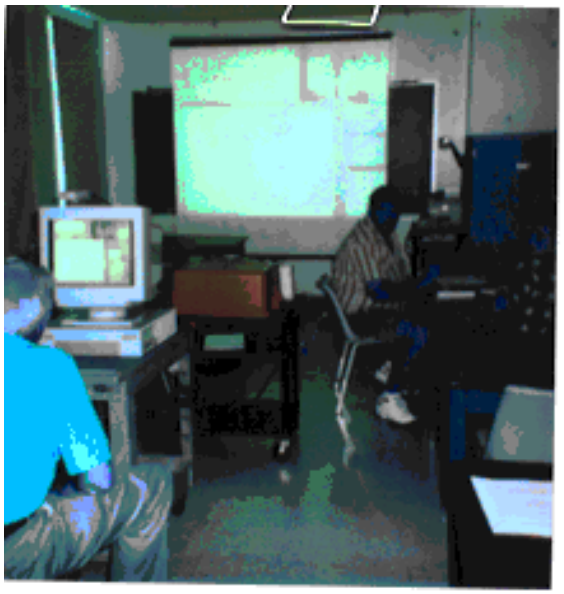

Figure 2: A Brainstorming Session at UNC-Asheville

Examinations for the remote students were held at the same time as local students during a live examination session. The instructor served as the proctor at NC State and the teaching assistant served as the proctor at the remote site. All examinations were graded at NC State. (This was the case for the traditional distance education course as well.)

Conclusions

This paper has presented details of a distance education course in computer engineering taught at NC State University to students at the University of North Carolina at Asheville. This course was taught using synchronous delivery techniques during the first semester of our experiment. The course and was taught using both asynchronous and synchronous delivery mechanisms in the subsequent semester of our experiment. The major conclusion of the experiment was that there was no statistical difference in the performance of the students at the local and remote sites. Hence, the distance education courses were generally a success. In fact, the instructor felt that the students at the remote site had an advantage over students at NC State since they had a smaller class size and had access to a special teaching assistant. Additional details of a complete evaluation of the qualitative perceptions of both faculty and students participating in the course can be found in (Brawner 1997).

There were many lessons learned from this experiment in distance education. The most important lesson was that retired engineers

provide an untapped resource for teaching assistants that are beneficial to universities and students. Unlike traditional teaching assistants, these assistants do not have other classes to take. In addition, they serve as an advocate for the students. Another lesson was that project-based courses are more difficult to teach as distance education courses since remote sites may have slightly different hardware/software than the local site. In this case, problems can arise that software support personnel at the local site cannot recreate the problems experienced at the remote site to provide efficient diagnosis to remote students. Also, remote sites may not have personnel with the same expertise on software/hardware used in a distance education course. While the MBONE software proved to be better for a distance education course than using the traditional closed-circuit television network, problems did arise that prohibited class from being held on a few occasions. Since the number of times this occurred was small, it was felt that broadcasting the course on the Internet was much less costly than providing staff to deliver courses over the closed-circuit television network.

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