Distance Learning in Architectural Engineering: An Inter-Institutional Case Study

Craig A. Bernecker, Ph.D., FIES, Walter Vincent, and Nipha P. Kumar
Penn State University/Tennessee State University

Higher education is undergoing profound changes nationally and globally due to current demographic, social, economic, and technological changes. These include declining enrollments[1], increasing costs, rapidly changing technical tools and information, and new types of students with new needs and varied learning styles[2, 3]. Simultaneously, digital telecommunications and computing technologies are converging to create a unified communications environment with implications for work, home, and education.

Taken together, these conditions have created a need for innovative approaches to curriculum design and content, as well as instructional delivery. Currently, the most powerful force for meeting this need appears to be the rapidly advancing field of distance education or what is often also referred to as distance learning.

Distance learning is becoming an increasingly viable means to deliver formal education to geographically diverse groups. It is also appropriate when education in specialized disciplines is offered at a select few institutions and faculty expertise and resources are limited. The discipline of architectural engineering appears to meet these criteria. This paper reports on an effort to formalize an approach to distance learning for architectural engineering. In particular, it describes an effort of institutional cooperation in distance education: taking advantage of a specialized expertise in illumination engineering at one institution to deliver education cooperatively to students at two institutions simultaneously. The paper examines the different types of distance learning and the issues that need to be addressed to apply distance learning to illumination engineering and architectural engineering education, explores available tools and technologies for distance learning, and describes the process of creating an inter-institutional distance learning offering. Examples of each distance learning technology implemented for the course are included in the paper. The paper also compares the relative performance of students as either resident or distance students against a baseline evaluation conducted at the beginning of the course. The objective of the paper is to offer a model for distance learning in lighting and architectural engineering that might be adapted for other offerings.

Defining Distance Education/Learning

What is distance education/learning? A simple, albeit redundant, definition offered by Shale[4] describes distance education as education that takes place at a distance. This attribute of physical distance is the key variable most often associated with distance education course development. 'Noncontiguous' is the word that Shaba[5] uses to describe this physical separation between instructor and learner. However, as one becomes more involved in designing instruction in a distance environment, other pedagogical issues emerge. Should distance course work development, as Keegan[6] suggests, attempt to 're-create' the face-to-face teaching and learning

experience that takes place in the traditional classroom? Further, what kinds of learning experiences can be included?

Moore and Kearsley[7] expand the definition of distance education to suggest that not only is distance education "planned learning that normally occurs in a different place from teaching," but also that "as a result [distance education] requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements." Thus it appears clear that the whole concept of distance learning involves much more than simply transposing what one conventionally does in the classroom.

An Interdisciplinary Case Study

Program Initiative

The notion for inter-institutional cooperation between the architectural engineering departments at the respective universities was conceived more than five years ago by the two department heads at the time. The driving forces behind this idea were that architectural engineering is a fairly rare discipline with only a few institutions offering programs in this discipline, that qualified faculty to teach architectural engineering were (and remain) limited and as a result the programs differed considerably in emphasis, and finally, since the two institutions differed dramatically in size, location, and composition of faculty and student body, a sense that working together might enhance the diversity of each institution in a very non-traditional fashion.

University Profiles

The participating universities were a large eastern university and a smaller southern university. The large eastern university has a population of more than 70,000 students spread across the state at eighteen locations. Over 37,000 of these students are located at the main university campus which is located in a town of approximately 39,000 residents. The University town is surrounded by rural and agricultural areas. Architectural Engineering is one of eight departments in the College of Engineering, one of ten academic colleges at the University. Architectural Engineering is a five year undergraduate program with a terminal degree of Bachelor of Architectural Engineering. The Bachelor of Architectural Engineering degree requires a minimum of 168 credit hours. The Department also has Master of Science, Master of Engineering, and Doctor of Philosophy degrees. The student population consists of approximately 360 undergraduates spread over the last four years of the program (a quota of 90 students are admitted at the beginning of the sophomore year). There are about 30 graduate students enrolled in the various degree programs in a given year. Students in the undergraduate program emphasize one of four option areas beginning in the fourth year: structural systems, mechanical systems, lighting/electrical systems, or construction management. The course described here is part of the lighting/electrical curriculum offered during the third year of the program to all students prior to the selection of their option. The number of students choosing the lighting/electrical option has ranged from ten to twenty-two students a year over the past ten years.

The smaller, southern university has a population of 8,625 students and is located in a

metropolitan area of over 500,000 residents. The University is situated in the central portion of the city, surrounded by commercial and residential neighborhoods. Architectural Engineering is one of five departments in the College of Engineering and Technology, one of seven schools/colleges at the University. Architectural Engineering is a four year undergraduate program with a terminal degree of Bachelor of Science in Architectural Engineering. The Bachelor of Science degree requires a minimum of 138 credit hours. The Department offers no graduate degrees. The student population consists of approximately 126 undergraduates. Students in the undergraduate program may select one of two option elective emphases: structural systems design or building systems design. Each emphasis consists of a minimum of six credit hours, although blocks of eight and nine hours are recommended for the building systems and structural systems emphases, respectively.

Both institutions are state and land grant universities which means they have a rich heritage of and mandate to service the needs of the public, particularly in their state or commonwealth. The smaller southern university is also a historically black institution.

Course description

The first course chosen for delivery as part of the inter-institutional effort was a course covering fundamental illumination and electrical systems design for buildings. The objective of the course is to provide students with the ability to design basic lighting and electrical systems for buildings and includes a study of fundamental principles, vocabulary, characteristics of system components, and basic design criteria and analysis techniques for both types of systems. At the originating institution, this is a three credit hour course offered every semester as part of the core curriculum for all architectural engineers, regardless of option. Generally 50-60 students are enrolled in the course at one time. Normally, the course is offered three times a week in fifty minute lecture sessions. It is typically taken during the third year of the five year undergraduate degree program. In fact, concurrent with the distance education offering of the course, a separate, fully resident section was offered at the originating institution, with a class size of 50 students.

The receiving institution has offered a similar course every fall semester as a building systems design option course. However, no regular member of the faculty has a formal background in illumination or electrical engineering, so this course has primarily been taught by an adjunct professor.

Course logistics

One of the difficulties in scheduling the course was that there was a difference in length of the respective semesters at the two institutions - the originating institution uses a fifteen week semester while the distance institution uses a 14 week semester - and the fact that the distance institution began classes two days prior to the originating institution. This was handled in two ways. First, the difference in starting date meant that there was one day of class held at the distance site prior to the start of classes at the originating site. This provided an opportunity for the faculty member teaching the course to travel to the distance site and introduce the course to the distance students in person. The visit proved invaluable in helping the distance students feel more comfortable with the instructor and for the instructor to learn the names and become

familiar with the students more quickly. It also provided an opportunity to photograph the students for the web page described later.

The difference in length of the semester was handled by adding three additional classes, held during evening hours, which were also videotaped for those students who might not be able to attend the extra sessions. These sessions were spread throughout the semester to minimize interference with other activities. This meant, however, that the distance institution students were actually taking more class sessions than they normally would during the fourteen week semester. Although both institutions were sensitive to this fact, there were no apparent concerns about this issue expressed by the students.

Another difficulty in scheduling the course was a difference in class meeting times, particularly given an hour time difference between the two institutions. The originating institution operates on a schedule of three classes a week (typically Monday, Wednesday, Friday) offered for fifty minutes each or two classes a week (typically Tuesday and Thursday) offered for seventy-five minutes. The distance institution operates on a similar schedule, however delayed by a one hour time difference. Since the distance section of this particular course was to be offered twice a week, this meant a seventy-five minute session on Tuesday and Thursday, respectively. Scheduled meeting times for such classes at the originating institution would be 8:00 - 9:15AM, 9:45-11:00AM, 11:15-12:30, etc. The second time slot appeared to be the most viable, since it would occur from 8:45-10:00 at the distance institution given the time difference. This did interfere with an 8:00AM class that some of the distance students were taking, but the instructor of that class was gracious enough to allow the students to leave early, except for a few occasions when they were simply a few minutes late for the distance class (not much different from some resident courses).

Distance Education Elements

The history of distance education appears to be predominantly technology-based, i.e. availability of a new technology drove new developments in distance education. However, as new technologies have proliferated, the focus has changed from technology-driven to learning-driven distance education as researchers and instructors have begun to consider which technologies can best support the learning environment. Thus, the choice of technologies to deliver distance learning should be based upon how they help achieve a particular aspect of learning rather than the technology itself. In other words, the choice of technologies to deliver education need to evolve from the educational objectives of the learning that is to take place.

In the case of this course, the main objective is to enable students to perform basic lighting and electrical design for buildings. In order to achieve this objective, learning must take place on several levels. For example, there is the need to build a knowledge base about lighting and electrical system components, the need to understand and apply design criteria and code restrictions, the need to be able to develop design concepts and alternatives, the need to conduct analyses of the systems to implement the design concepts, the need to communicate design through drawings and specifications, and the need to be able to synthesize all of these abilities into a contiguous design process. Meeting many of these needs involves a number learning modes and requires a fairly interactive and in many cases, a visual learning process. As a result a

number of distance education elements were chosen for delivery of learning in this course and in turn a number of technologies were used. This is in contrast to many distance education offerings which fix on one mode of delivery and/or technology, such as the current proliferation of web courses. Four elements were chosen to support various aspects of learning in this course.

Lectures were offered through two-way video-conferencing concurrently to resident and distance students in the course. The video-conferencing capabilities at the delivery site consisted of two television monitors at the front of the room with a "U"shaped arrangement of tables facing the monitors. The instructor sat at the far end of the "U," with students arranged along either leg. This permitted the students to watch either the instructor or the monitors with equal ease. A wide-angle camera was located above one of the monitors; the camera could be remotely controlled to zoom in on the instructor or any one of the students, or panned back to see the entire room. A third monitor was located to the right of the instructor in the corner of the room to provide yet another view for the students. One of the monitors at the front of the room and the monitor in the corner of the room displayed what was being presented at the delivery site, while the second monitor displayed the class at the receiving site. The position of the camera above the second monitor allowed the instructor to view students at the receiving site at the same time he was speaking to the camera. This enhanced the appearance that the lecture was being delivered directly to the distance students.

The video-conferencing system provides a remote control panel which allows the instructor to directly control the view seen by the students. Direct inputs to the system included a document camera and a laptop computer. The document camera allowed for the use of figures or graphs to be shown directly to the students, much in the way an overhead projector might be used in a typical classroom. However, the document camera had the further advantages of projecting good color, zooming in on very small detail, and allowing objects or even textbooks to be projected. Thus, samples of lamps and electrical devices could be shown directly and students in both classrooms could see detail much better than a typical classroom.

The laptop computer allowed for many class notes to be presented through computer-aided presentations rather than hand-written on a chalk or white board. In fact, the use of such presentations was a major element of the course. Rather than require students to take copious notes, much of the information was pre-printed in a set of slide notes with essential information left blank. This allowed students to listen attentively while only recording key points, terms, etc.

Faculty-student, student-faculty, and student-student communication was accomplished primarily through electronic mail. This allowed students to ask questions of the instructor at any time, to discuss issues with other students, or interact on project work with one another. This communication was important because a major element of the course was a team design project. Designed to foster interaction, two students from each university were assigned to work on the same team.

General group communication and the posting of course information was accomplished through a home page on the World-wide Web. The home page included the course syllabus, grading information, project assignments, sample homework and projects, and links to information about

the instructor. A special effort was made to digitally photograph all students which allowed the posting of a personalized class roster with photos. It was hoped this would allow the students to get to know each other better, perhaps even more so than in a standard classroom.

Finally, *course organization and protocol descriptions, instructions in the use of technologies, and the lecture notes* were all prepared in print form. It was believed the use of this traditional medium was essential to the success of the course.

Field Trip

Although unplanned at the beginning of the course, what proved to be an invaluable part of the course was a field trip made by the distance students to the originating institution to participate in the annual career fair held by that Department. More than seventy-five companies participated in the career fair, setting up booths in the student union building and providing contacts and information for students, as well as interviewing some students at the completion of the fair. The visit provided the opportunity to teach almost of the students (three distance students were unable to make the trip) in the same classroom, in person, once during the semester. This seemed to add to the positive atmosphere surrounding the course. In addition to the one class and the career fair, the distance students were treated to a reception by the College of Engineering. The visiting students were also hosted by several students at the home institution, providing overnight accommodations for the bulk of the students.

Student Profile

Eleven students participated in the course as distance students while eight students were resident students at the originating site. The distance students were all senior students with the exception of one junior student (i.e. in the fourth and third year of the program, respectively), while the resident students were mostly in the third year of the five year program, or the equivalent of a typical college junior, with one student in the fourth year of the program. There were two females and nine males at the distance site and two females and six males at the originating site. One of the females at the originating site did not complete the course, although she participated until the last week of the semester.

Course Assessment

An assessment of the progress made by students in the respective sections of the distance learning course, and more importantly, a comparison of the effectiveness of the instruction was impossible without a baseline measure of their knowledge and understanding of the content area of this course. Thus, a twenty question pre-test was developed which each student was asked to complete during the first week of the course. The pre-test consisted of questions which ranged in difficulty and covered both content areas of the course. Students were asked to answer only those questions they thought they knew and leave the remainder blank rather than guessing. This prevented the possibility of guessing right from inadvertently biasing the results.

The remainder of the assessment methods consisted of the regular content evaluation techniques used in the course -- mid-term and final exams, project and homework grades -- and the standard student evaluations completed at the end of any course offered at the originating institution. The latter evaluations, called Student Ratings of Teaching Effectiveness (SRTE's), allow the students

to rate the course on a set of sixteen, seven-step evaluative scales.

The results of the content evaluation techniques and the SRTE's are shown in Tables 1 and 2 respectively.

An evaluation of the effectiveness of the course was made by conducting paired comparisons of the mean scores for each assessment method of the students in the host classroom versus those in the distance classroom. Overall, there was no difference in the baseline measure between the two groups, some differences in performance measured by traditional content evaluation techniques, and relatively few differences in the students' evaluation of the course. The performance differences are attributed to differences in the abilities of the two groups, particularly given little difference in the ratings of effectiveness of the course and teaching methods.

Given these results, it appears that learning at a distance is a viable means for delivering architectural engineering education. There appears to be little difference in either the ability to learn or the perception of the ability to learn. Certainly there are ways to improve upon distance delivery as it was conducted in this course. However, even on a trial basis, the departments at both institutions were pleased with the results of the effort, as were the students as judged by both their anecdotal comments along with their more formal evaluations. It is intended to repeat the course in a subsequent year with more specific assessments, which will allow for more objective data to be collected to assess such an initiative.

Table 1. Summary of grading for distance, distance-resident, and resident sections

	Mid-Term	Homework	Project	Final	Overall
Distance-Resident Section					
(8 students)					
Mean	76.25	80.9 (7)	85.6 (7)	79.0 (7)	79.57
Standard Deviation	12.83	11.46	0.9	11.64	9.01
Range	93-54	95-32	87-85	98-62	93-64
Reliability	0.853	--	--	0.791	--
Distance Section					
(11 students)					
Mean	61.18	86.5	82.27	61.73	69.31
Standard Deviation	14.08	5.76	1.86	11.60	8.48
Range	95-43	100-68	85-80	86-46	89-59
Reliability	0.883	--	--	0.787	--
Resident Section					
(48 students)					
Mean	81.63	xx.xx	89.06	78.74	83.09
Standard Deviation	8.33	x.xx	2.26	8.57	4.86
Range	97-55	xx-xx	93-85	95-50	93-70
Reliability	0.747	--	--	0.651	--

Table 2. Summary of Student Ratings of Teaching Effectiveness (SRTE's)

	Distance/Resident Section	Distance Section	Resident Section
1. Rate the overall quality of the course.	5.4	4.3	5.2
2. Rate the overall quality of the instructor.	6.0	5.3	4.8
3. Rate the clarity of the instructor's presentations.	5.2	5.5	5.4
4. Rate the instructor's skill in using examples and illustrations.	5.8	5.8	5.3
5. Rate the instructor's willingness to help students make progress.	6.2	4.8	4.1
6. Rate the instructor's willingness to listen to students' comments and questions.	6.4	5.4	4.5
7. Rate the adequacy of the instructor's knowledge of the subject matter.	6.6	6.1	6.3
8. Rate the effectiveness of the instructor's discussions of professional ethics and responsibilities.	6.4	5.5	5.0
9. Rate the organization of course material.	5.6	5.3	5.5
10. Rate the effectiveness of the instructor in demonstrating the significance of the subject matter.	5.6	5.0	5.1
11. Rate the fairness of the overall grading system in the course.	5.2	3.9	4.7
12. Rate the appropriateness of the instructor's encouragement of student participation and instruction.	5.6	5.3	4.2
13. Rate the amount of interest generated by the instructor's style of participation.	4.8	5.1	3.6
14. Rate the appropriateness of the instructor's teaching methods to allow students to achieve course objectives.	5.0	4.8	4.4
15. Rate the instructor's skill in encouraging students to think.	5.2	5.0	4.5
16. Rate the importance of the knowledge learned in this course.	5.6	5.3	5.5

References

1. American Council on Education, Higher Education & National Affairs (January 8, 1996) vol.45.1.

2. Blumenstyk, Goldie. "Networks to the Rescue?" The Chronicle of Higher Education (December 14, 1994):A21-22

3. Schroeder, Charles C. "New St . In M.G. Moore, & C.G. Smith (Eds.), Readings in principles of distance education (pp. 344-352). University Park, PA: The Pennsylvania State University.

4. Shale, D. (1989). Toward a reconceptualization of distance education. In M.G. Moore, & C.G. Smith (Eds udents-New Learning Styles." Change (September/October 1993):21-26.

5. Shaba, F. (1989). Integrated telecommunications systems and instructional transaction.

6. Keegan, D. (1989). A theory for distance education. In M.G. Moore, & C.G. Smith (Eds.), Readings in principles of distance education (pp. 327-332). University Park, PA: The Pennsylvania State University.

7. Moore, M.G. & Kearsley. (1996).

CRAIG A. BERNECKER is Associate Professor of Architectural Engineering at Penn State University, specializing in illumination engineering. He is a Fellow of the Illuminating Engineering Society of North America and has served as its Vice President of Technical and Research Activities and Educational Activities, respectively. He is Vice Chair of Penn State's Outreach Committee and a Faculty Fellow for Penn State's Innovations in Distance Education project.