Distance education in nuclear engineering at the University of Tennessee

BY H. L. (LEE) DODDS

Preliminary results have been quite positive from the point of view of both the students and the university.

THE INTERNET AND other advances in telecommunications are spawning a small revolution in higher education. Students no longer must attend classes in person with their professors, although this paradigm will probably always be the first choice of most students and most professors. Instead, lectures and classroom discussions can be delivered live and interactively to the student's computer, which may be located anywhere the student can access the Internet—from home, the office, or from the side of a mountain in Nepal (via a satellite connection).

This newfound model for pursuing higher education is quite appealing to a large segment of society, especially working professionals who are not conveniently located near a university, or who have job or family responsibilities that preclude attending classes in person. Of course, distance education is not new. Correspondence courses have existed for many decades and, in the past decade, courses have been delivered by standard videoconferencing using ISDN or other dedicated high-speed connections and equipment, which are quite expensive. The Internet, however, is free (almost) and, more important, it enables the delivery of quality education programs to working professionals and any others who, for whatever reason, choose not to attend classes in person.

In order to take advantage of educational opportunities made possible by the Internet, the University of Tennessee Nuclear Engineering (UTNE) Department at Knoxville has developed four distance education programs that are Internet-based: (1) the Master of Science Degree in Nuclear Engineering, (2) a Graduate Certificate in Nuclear Criticality Safety, (3) a Graduate Certificate in Maintenance and Reliability Engineering, and (4) a weekly seminar, or colloquium, series.

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Fig. 1. UTNE instructor Wes Hines (left) teaching a graduate course for both local and distance students. UTNE local students (at right, left to right) are Aaron Sawyer, T. Jay Harrison, and Cindy Jones. (UT photo by Larry Miller)

All four programs are delivered live and interactively (i.e., synchronous delivery) over the Internet to the recipient's computer. Asynchronous delivery is also available to individuals who must occasionally miss a class or seminar, since all synchronous classes and seminars are saved and archived on a server.

The seminar program is actually free and available to anyone, not just to UTNE students, via Webcasts (see <www.engr.utk.edu/nuclear/Seminar>). Participation in the first three programs, however, requires admission as a graduate student and payment of university fees. Also, programs (1) and (2) are intended primarily for nuclear engineering students, whereas program (3) is an interdisciplinary program that currently includes industrial engineering, mechanical engineering, and nuclear engineering. Most important, the distance classes are identical to the classes that are offered in the traditional classroom setting to local students on campus, which means that the quality of the distance education programs is essentially the same as that of the on-campus programs.

M.S. in nuclear engineering

The M.S. program for distance students is the same as UTNE's traditional M.S. program for local students, but with fewer courses offered. The M.S. program officially began in fall 2001. It requires eight three-hour graduate courses: four Nuclear Engineering (NE) courses, two courses in a related technical discipline (or two more NE courses), and two courses in mathematics, statistics, or computer science. In addition, at least six hours of research or engineering practice are required for a total M.S. requirement of at least 30 hours.

The courses that are currently available to NE distance students are: Fundamentals of Nuclear and Radiological Engineering, Reactor Theory I, Radiation Protection I, Reactor Theory and Design, Advanced Radiation Protection, Reactor Shielding, Monte Carlo Analysis, Radiological Assessment and Dosimetry, Introduction to Nuclear Criticality Safety, Nuclear System Design, Selected Topics in Nuclear Criticality Safety, Advanced Monitoring and Diagnostics, Introduction to Maintenance Engineering, Introduction to Reliability Engineering, Statistical Methods, and Applied Linear Models in Statistics. Additional courses will be offered in the future. Also, up to one-third of the credit hours for the M.S. degree can be transfer credit from other recognized university programs.

M.S. students must also register for at least three hours of research or engineering practice during any semester in which research or engineering practice is conducted, to satisfy degree requirements. Proposed projects, either thesis research or engineering practice projects, may (or may not) be related to the student's current job, but must be approved *a priori* by the student's major professor and graduate committee.

To obtain approval, a brief proposal written by the student must be submitted to and approved by the student's major professor and graduate committee at the beginning of the proposed project. The student must also write brief monthly progress reports, which are submitted to and approved by the student's major professor. The student may have an onsite advisor or mentor to help direct the student's work along with the overall supervision provided by the major professor. Acceptance of the student's work in satisfying degree requirements, however, is solely the responsibility of the student's major professor and graduate committee. Good research and engineering practice projects frequently lead to external publications that are coauthored by the student, the onsite advisor, and the major professor. At the conclusion of the M.S. program, students come to the UT main campus to defend their work, both coursework and thesis or engineering practice project reports, in a comprehensive oral exam in front of their major professor and graduate committee.

Most distance students should complete all of the requirements for the M.S. degree in nuclear engineering, both research and coursework, in two calendar years. A typical two-year program could involve taking eight courses over six consecutive semesters: one per semester for four semesters and two per semester for two semesters. Research would also be conducted during most of the six semesters in order to finish within two years. Some students, however, may prefer a slower pace, while others may prefer a more accelerated pace. The program is designed to accommodate both student preferences.

Certificate programs

Each of the two certificate programs consists of four three-hour graduate courses and does not include a requirement for research or engineering practice. Thus, each certificate program requires about half of the coursework needed to obtain the M.S. degree.

The four courses required for the Nuclear Criticality Safety Certificate are Introduction to Nuclear Criticality Safety, Selected Topics in Nuclear Criticality Safety, Monte Carlo Analysis, and one of the following three elective courses: Reactor Theory I, Reactor Theory and Design, or Reactor Shielding.

The four courses required for the Certificate in Maintenance and Reliability Engineering are Introduction to Maintenance Engineering, Introduction to Reliability Engineering, and two elective courses selected from the following list: Advanced Monitoring and Diagnostics, Process System Reliability and Safety, Mechanical Vibrations, Reliability Centered Maintenance, Statistical Methods in Industrial Engineering, and Managing Maintenance and Reliability.

The Maintenance and Reliability Certificate program is actually a college-wide program, which currently includes elective courses in mechanical engineering and industrial engineering, as well as nuclear engineering. Both of the Certificate Programs are intended to provide a good theoretical and analytical foundation for on-the-job training and experience that is required of most practitioners. Any of the courses in the two certificate programs may also be used toward satisfying M.S. degree requirements.

Admission requirements

Admission requirements are essentially the same for all three graduate programs; namely, a B.S. in any engineering discipline, physics, chemistry, or mathematics from an accredited program with at least a 3.0/4.0 GPA. In addition, all entering students for both the M.S. program and the Nuclear Criticality Safety Certificate program must have, as a minimum, competency in mathematics through ordinary differential equations and competency consistent with an introductory course in nuclear engineering. If these competencies do not exist, students must take appropriate courses to develop the competencies prior to beginning a program.

The recommended course of study for each individual student is determined by an advising conference with the student and depends on the student's professional interests, academic background, and work experience.

The cost for either of the three programs is the standard semester fee schedule for graduate studies at UT and is described in detail in the current Graduate Catalog, which is available online at <web.utk.edu/~gsinfo/>. More detailed information about the three graduate programs is available at <www.anywhere.tennessee.edu/ne/default.htm>.

Seminar program

The purpose of the seminar, or colloquium, program is to broaden and invigorate the intellectual atmosphere of the department by inviting experts from outside of the department to share their knowledge and expertise with our students, faculty, and seminar guests. The seminars are usually nuclear-related, but not always, because UTNE occasionally likes to "think outside of the nuclear box."

The seminars are Webcast live and interactively over the Internet (see <www.engr.utk.edu/nuclear/Seminar>). The Webcasting of UTNE seminars began in fall 2000. The digital file that is Webcast as a live seminar is also captured electronically and saved on a server as a permanent archive. Viewing either a live seminar or an archived seminar requires a media player, such as RealPlayer™, installed on the viewer's computer.

Interactivity by the "cyber audience" during a live seminar is accomplished by sending e-mail messages containing questions or comments to <utne@tennessee.edu>. The messages are printed and handed to the seminar moderator who reads the messages aloud at the end of the seminar during the question-and-answer period. The speaker then answers the questions from the cyber audience during the live Webcast along with other questions and comments from the local audience.

Needless to say, the seminar program is an important outreach activity for the department. Colleagues from outside of the university, UTNE alumni, prospective students, high school science teachers, and anyone else who has an interest in a particular seminar can "tune in" to the live Webcast or to an archived Webcast. Two excellent examples of UTNE seminars of general interest were presented by nuclear pioneer Alvin Weinberg, the first on September 20, 2000, titled "People and Personalities in the Manhattan Project," and another on September 5, 2001, "Enrico Fermi and the World's First Controlled, Self-sustaining Chain Reaction." These two seminars, along with other UTNE seminars that were presented over the past two years, are archived on the UT Web site at <www.engr.utk.edu/nuclear/Seminar/Archive/> and are currently available for viewing.

Delivery technology

Synchronous delivery of classes over the Internet (i.e., Cyberclasses) is accomplished with software developed by Centra Software, Inc. (<www.centra.com>), which is provided to distance students by the UT Division of Outreach and Continuing Education. Cyberclasses offer audio that is similar to a telephone conference; a shared electronic whiteboard that allows group collaborations; and online notes,

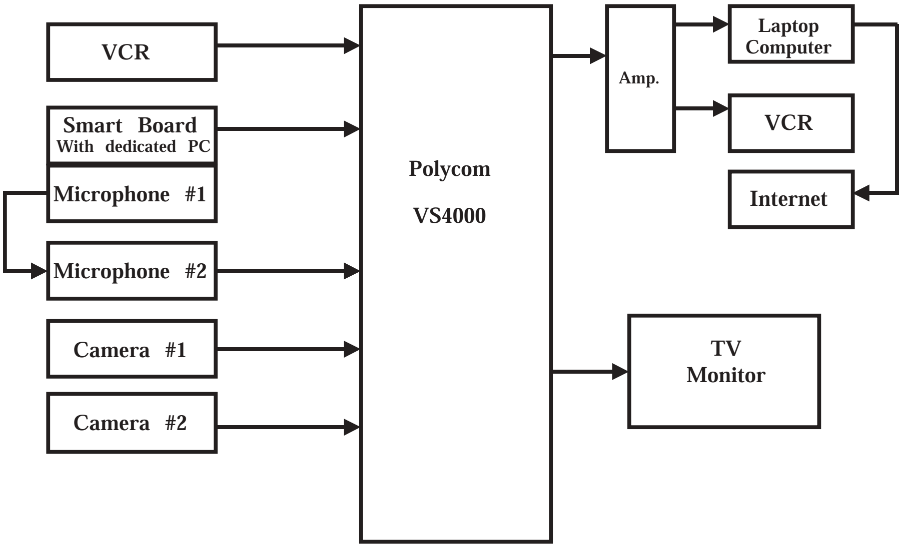

Fig. 2. Equipment setup for seminar Webcasts (UT)

quizzes, and discussion boards that may be accessed by students and faculty anytime anywhere.

Faculty usually teach using PowerPoint™ slide presentations or dedicated Web pages. The electronic whiteboard, which is equivalent to a chalkboard, is used for working problems and presenting visual examples. Windows™-based programs are used for complex simulations and demonstrations.

PowerPoint files and other file types are uploaded to a server by the instructor before each class and then downloaded to the student's computer during student logon at the beginning of each class. This initial transfer of class material reduces the bandwidth requirements during the actual class.

Students are able to interact with the instructor and classmates in real-time by asking and answering questions, providing feedback, and making class presentations. The Centra software also allows chat windows during class and breakout sessions for group projects. More detailed information about the Web delivery technology is available at <www.outreach.utk.edu/deis/online/webdelivery.htm>.

UTNE professors initially taught distance classes from their offices using their office computers, which are connected to the Internet via a high-speed LAN (Local Area Network) and are equipped with microphones and speakers. Professors simply shut their office door during a Cyberclass and put a sign on their door that said "In–class, do not disturb."

More recently, UTNE has combined the distance students with local on-campus students into a single "hybrid class" using a SMART Board™ rear projection unit as shown in Fig. 1. The SMART Board system includes a 67-inch diagonal touch-sensitive rear-projection screen (whiteboard) with speakers, which is driven by an internal Web-connected PC. Tapping on the screen is equivalent to a mouse click and writing on the screen is accomplished with electronic pens.

In the hybrid class example shown in Fig. 1, the instructor, Wes Hines, is performing a demonstration of "fuzzy clustering" to both local and distance students as part of his graduate course on Advanced Monitoring and Diagnostic Techniques. The local students in the classroom see and hear the same information as the distance students and simultaneously with the distance students. Both local and distance students verbally ask questions and receive answers in real time, which are shared by all students in the class. In short, the SMART Board and Centra technology used together insure a quality, interactive learning experience for both local and distance students. More information about SMART Boards is available at <www.smarttech.com>.

The delivery technology for the seminar program is somewhat different. The SMART Board projection unit with the internal PC is again used to display the speaker's PowerPoint slides to the local audience. Also used are two remotely controlled digital movie cameras, two conference microphones, a Polycom VS4000™ videoconference unit, TV monitor, high-performance laptop computer, remotely controlled electronic mouse, and a very good technician who makes everything work. The equipment is connected as shown in Fig. 2. The signal sent to the Internet is controlled remotely by the technician in real time during the seminar and can be a PowerPoint slide or an image from either camera. RealProducer™ resides on the laptop computer and is used by the technician to assimilate the information for the signal that is sent to the Internet.

Needless to say, technical failures occasionally do occur with the seminar Webcasts because those involved (including this author) are novices at using this technology. Fortunately, most of the time the seminar Webcasts are successful, and there are constant efforts to improve their transmission quality and reliability.

A similar setup of the equipment using only the VS4000, TV monitor, one microphone, and one camera is used for videoconferencing over the Internet. Faculty can use this capability to get "face-to-face" with distance students (on a daily basis if necessary) to supervise research projects or answer questions about classes. Of course, a digital camera and appropriate software (e.g., NetMeeting™ from Microsoft) or a ViaVideo™ unit from Polycom (see <www.polycom.com>), or the equivalent, must be installed on the student's computer in order to take advantage of this capability. The videoconferencing setup of the equipment is also used to collaborate on research projects with colleagues outside of the university.

Benefits

Students who participate in any of UTNE's distance education programs gain state-of-the-art knowledge in their chosen field, are better qualified to work as professionals, and increase their value to their current employer and to prospective new employers. Students will also have the personal satisfaction and enjoyment of learning new concepts and developing new skills in exciting fields of national and international importance.

Michael White, an UTNE M.S. distance student and a full-time employee of the Knolls Atomic Power Laboratory (KAPL) in Schenectady, N.Y., said, "The UTNE distance education master's program is well-suited to my career at KAPL. I thoroughly enjoy the interactivity of the live on-line classes." Another UTNE M.S. student, Katherin Goluoglu, who resides locally and prefers to be a stay-at-home mom with her three-year-old daughter, said, "Attending class at home is ideal for me and our daughter, Ashley."

Although the distance education programs described in this article are still in the startup transition phase, preliminary results have been quite positive from the point of view of both the students and the university. Fall 2001 enrollment data at UT indicate that the new distance education programs increased nuclear engineering graduate student enrollment by 25 percent relative to the previous year. These figures reflect demand primarily for the M.S. program because the certificate programs, which begin officially in fall 2002, have not yet been formally advertised.

In summary, although attending classes and seminars in person is probably the first choice of most people, there is a genuine need for universities to provide high-quality distance education programs. More important, providing such programs in real-time using the Internet appears to be a rewarding and worthwhile activity not only for students, but also for universities. NN