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The Use of Information Technology in The University of Tennessee Nuclear Engineering Distance Education Program

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Abstract:
The Nuclear Engineering Department at the University of Tennessee offers three graduate programs that are available to distance students: the M.S. degree in Nuclear Engineering, a Graduate Certificate program in Nuclear Criticality Safety, and a Graduate Certificate program in Maintenance and Reliability Engineering. Most of the courses in the three programs are delivered synchronously (i.e., live and interactive) to the student's desktop computer via the World Wide Web using a virtual classroom software program called Centra Symposium™. The Centra software permits oral communication between instructor and students as well as oral communication among students. This interactive oral communication is usually accompanied by PowerPoint slides, video files, and video streaming of windows applications such as MATLAB or FORTRAN demonstrations. The synchronous classes are recorded and available asynchronously to accommodate students who must occasionally miss class. In addition to the on-line lecture classes, some laboratories are also delivered on-line.

1.0 INTRODUCTION:

The Accreditation Board for Engineering and Technology (ABET) lists nineteen universities that provide accredited B.S. degrees in Nuclear Engineering (NE), while the American Nuclear Society lists thirty-one universities with NE programs. The probability that a working professional is located geographically near one of these programs is quite small. In addition, traditional university programs offer most courses during the day which conflicts with the work schedules of most professionals. For these two reasons, it is extremely difficult for a working professional to obtain a quality education in Nuclear Engineering without taking a leave of absence from, or quitting, his or her job. With the availability of new web-based educational technologies, The University of Tennessee has developed a program that brings the classroom to the student, rather than having the student disrupt his/her life to travel to a university for an education[1,2]. The new programs that are described in this paper are designed to allow a working professional to remain with his or her family while acquiring new professional skills in nuclear engineering.

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2.0 DISTANCE EDUCATION PROGRAMS:

Three graduate programs have been developed and made available to distance students across the country and throughout the world:

- M.S. degree in Nuclear Engineering,
- Graduate Certificate program in Nuclear Criticality Safety,
- Graduate Certificate program in Maintenance and Reliability Engineering.

The courses are taught primarily by the University of Tennessee Nuclear Engineering (UTNE) faculty, but may also be taught by adjunct faculty from the nearby Oak Ridge DOE complex, including both the Oak Ridge National Laboratory and the Oak Ridge Y-12 Plant.

The MS degree comprises 30 to 33 graduate credit hours depending on whether a thesis or a non-thesis option is selected. The Graduate Certificate programs require four courses of 3 credit hours each. The credit hours earned in completing a certificate program can also be used towards an M.S. degree. The courses in the M.S. and certificate programs are also available to local students on campus.

The Advanced Monitoring and Diagnostic Techniques (NE 597) course was the first to be presented on-line in the Summer of 2000[3]. During its first offering it had attendees from other U.S. and international Universities. The class offering was funded by the National Science Foundation's Combined Research Curriculum Development Program and students were enrolled from The Colorado School of Mines, The University of Tennessee Memphis, Louisiana State University, and The University of Sao Paolo in Brazil. Courses were delivered synchronously through the use of the Centra Symposium Internet delivery system.

2.1 Master of Science Degree in Nuclear and Radiological Engineering

Distance students can complete the entire curriculum for the Master of Science in Nuclear Engineering program by taking primarily interactive web courses that are basically the same as graduate nuclear engineering courses taught on campus at The University of Tennessee (UT).

The degree requires 24 credit hours (eight 3-hour courses) of coursework including:

- 12-hours of graduate courses in nuclear engineering
- 6 additional hours in nuclear engineering or a related field
- 6 elective hours of mathematics statistics, or computer science

and the selection of one of the following research options:

- 6 credit hours of research through completion of a thesis
- 6 credit hours of research through engineering practice projects
- 3 hours of engineering practice project plus 6 additional hours of graduate nuclear engineering coursework.

Applicants without a B.S. degree in Nuclear Engineering, or the equivalent, must take the following three courses:

- *NE 301: Fundamentals of Nuclear & Radiological Engineering*
- *NE 431: Radiation Protection*
- *NE 470: Nuclear Reactor Theory I*

However, NE 431 and NE 470 can be used to satisfy M.S. degree requirements and may be taken simultaneously after the completion of NE 301. Each of these three prerequisite courses is offered by videotape in the Fall, Summer, and Spring semesters. Up to one-third of the credit hours required for the M.S. degree can be taken from 400-level classes, and up to one-third can be transfer credit from another accredited institution.

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 the two year period. However, some students may prefer a slower pace while others may prefer a more accelerated pace. The program is designed to accommodate both student preferences.

2.2 Graduate Certificate in Nuclear Criticality Safety (NCS)

Students can earn a Graduate Certificate in Nuclear Criticality Safety (NCS) by completing four graduate nuclear engineering courses (3 credits each). This certificate program is intended to complement practical on-the-job training that is required of most NCS specialists. The four courses are composed of the following three required courses:

- *Introduction to Nuclear Criticality Safety (NE 421*
- *Selected Topics in Nuclear Criticality Safety (NE 543)*
- *Monte Carlo Analysis (NE 582)*

and one of the following three elective courses:

- *Reactor Theory I (NE 470)*
- *Reactor Theory and Design (NE 571)*
- *Reactor Shielding (NE 581).*

More detailed information about the courses is available online at http://web.utk.edu/~gsinfo/nuc.htm.

2.3 Distance Graduate Certificate in Maintenance and Reliability Engineering

The Graduate Certificate in Maintenance and Reliability Engineering is a college-wide program that currently includes courses in industrial engineering, mechanical engineering, and nuclear engineering. Students earn the certificate by completing four graduate engineering courses (3 credits each). The four courses consist of two core courses:

- *Introduction to Reliability Engineering (IE/ME/NE 483)*
- *Introduction to Maintenance Engineering (IE/ME/NE 484)*

and two elective courses selected from the following list:

- *Statistical Methods in Industrial Engineering (IE 516*)
- *Managing Maintenance and Reliability (IE 591)*
- *Mechanical Vibrations (ME 534)*
- *Reliability Centered Maintenance (ME 599)*
- *Advanced Monitoring and Diagnostic Techniques (NE 579)*
- *Process System Reliability and Safety (NE 585).*

More detailed information about the Maintenance and Reliability certificate program is available online at http://anywhere.tennessee.edu/ne/gradcert/mre/default.htm.

3.0 METHODOLOGY:

The distance courses are delivered live and interactively (i.e., synchronous delivery) to the student's desktop computer via the World Wide Web and are recorded and available asynchronously (i.e. saved on a server) to accommodate students who must occasionally miss class. The software, developed and licensed by Centra Inc. (www.centra.com), is supplied by The University of Tennessee, Division of Outreach and Continuing Education.

3.1 CENTRA Delivery System

Internet CyberClasses use shared audio and video putting the student on-line with faculty and classmates worldwide, offering convenience unmatched in any other nuclear engineering degree program. CyberClass is real-time: the student sees and hears everything as it happens. Figure 1 is a screen shot of a Centra Symposium Class showing the in-class use of a windows-based program.

The Internet based interactive media features include

- Audio-over-the-internet for phone conference call-like interaction
- Synchronized web browsers for interactive use of the World Wide Web
- Shared electronic whiteboard allowing real time group collaborations
- VCR-like audio/video playback of previous CyberClasses over the Internet
- Online notes, quizzes, and discussion boards accessed by the students and faculty anytime and anywhere.

Many engineering professors teach with three main components:

- Powerpoint Slide Presentations for course content,
- Whiteboard (electronic chalkboard) for working problems and presenting visual examples,
- Windows based programs for complex simulations or visuals.

Each of these components is supported with Centra's Symposium™ software package. Powerpoint slide presentations, windows media files, and a number of other file types are uploaded to a server by the instructor and then downloaded to the student's computers when logging into the class. This initial transfer of lecture materials decreases the bandwidth requirements during class because only keys are transmitted to the students' computers to page through the lecture material. This frees up bandwidth for the real-time audio and other windows applications.

Students are able to interact with the class by asking questions, providing feedback, and through the opportunity to make class presentation. The software also allows chat windows during the class and breakout sessions for group projects. Initial feedback from the distance students has been very positive.

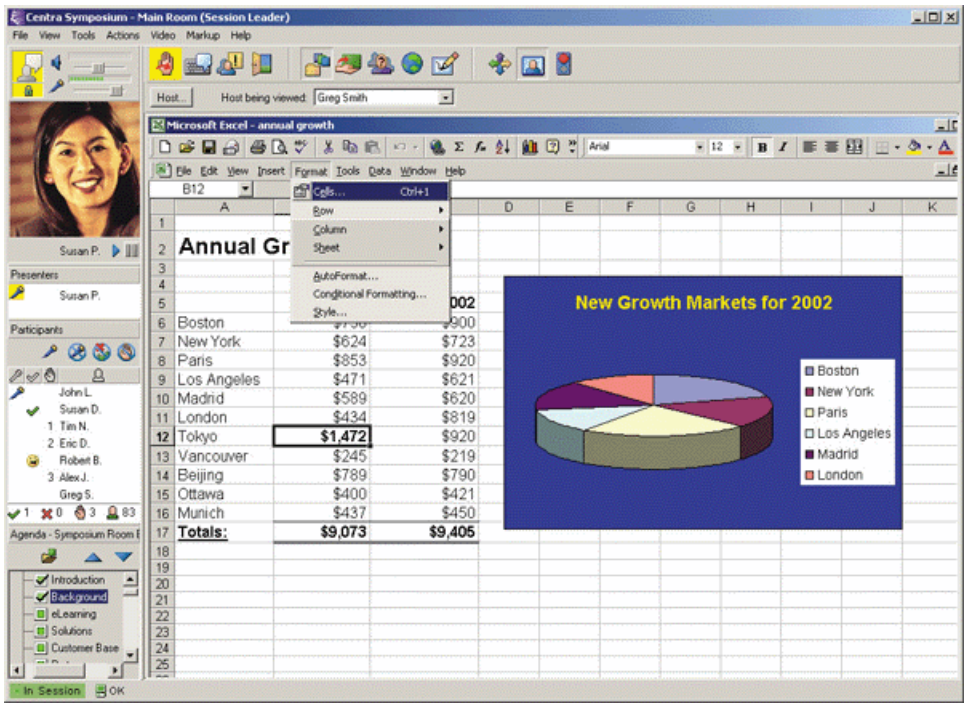

Figure 1. Centra Symposium Screen Shot

The typical class enrollments are currently six distance students coupled with six local students. Because of these fairly small initial sizes, we have combined the distance and local sections into one course offering. Initially, the local students attended the class through a computer connection just as the distance students. Recently, we have combined the classes in a different way. The College of Engineering has just completed the purchase and installation of SMART Board systems for all of the engineering classrooms. These SMART Board systems (see Figure 2) consist of an interactive 67" touch sensitive rear projection screen (whiteboard) that acts as an input/output interface to an web connected PC computer. Tapping on the board is equivalent to a mouse click and writing to the whiteboard is accomplished with electronic pens. Additionally, screen shots can be captured and class lectures can be recorded for posting to a class website. More information on SMART Board technology is located found at http://www.smarttech.com/.

Figure 2. SMART Board Rear Projection Unit

The addition of these SMART Boards to engineering classrooms allow the faculty member to teach with the Centra Software to distance students with local students attending in the classroom. The instructor wears a wireless microphone and uses the SMART Board as the computer interface to the distance students. The distance students can participate in class discussion by raising their hand and asking questions as easily as the local students. The distance students can also have access to the whiteboard and other windows application on the host computer. This offers both local and distance students a choice of learning environments with the result being a quality, interactive, learning experience.

3.2 Laboratories

One possible difficulty encountered with distance-based, engineering education is the incorporation of realistic, interactive, laboratory experiences. This experience is essential to the successful distance delivery of some engineering courses. We have identified three techniques to provide the laboratory experience at a distance:

1. Through a Remote Laboratory based on remotely controlled instruments.
2. Through a Virtual Laboratory via simulation.
3. Through a cost-effective mail-out laboratory.

The Remote Laboratory is based on a collection of instruments interfaced to a set of personal computer systems connected to the Internet. Under this approach, students can perform their experiments by accessing and operating instruments at a distance. The major benefit is the enhanced flexibility afforded to the students through the removal of geographic and time constraints normally associated with laboratory education. The virtual lab can maximize utilization of instrumentation at minimal cost and security risk. The remote control of experiments accessible through a virtual lab provides the students with a glimpse of the future research mode, especially at multi-user facilities such as Oak Ridge National Laboratory. Although the remote laboratory approach is considered to be cost-efficient, distance student population and budgetary constraints may render the full implementation prohibitively expensive. The full implementation of all laboratory experiments may require multiple instruments or machines, large numbers of samples, and a full-time technician; therefore, alternative methods are also being considered. For more information on remote laboratories, please see the work by Dr. Jim Henry[4,5], University of Tennessee-Chattanooga College of Engineering and Computer Science or visit the website www.reallabs.net.

A simulation approach can also be used to provide the laboratory experience. The simulation approach is a cost-effective method of providing students an opportunity to learn the principles by using carefully designed experiments. Under simulation, the students work within established guidelines and a previously collected data package. A large number of students can be served simultaneously through laboratory simulation with the learning experience still being of high quality.

A third method is that of small, cost-effective, mail-out laboratories. This may be thought of as a "laboratory in a shoebox" and is a method that allows the student to be truly "hands-on" when necessary.

Experiments in the first course to be developed (*Advanced Monitoring and Diagnostic Techniques, NE 579*) have been broadcast on-line through the use of National Instrument's

LabView Internet Development Toolkit (www.ni.com). This technology allows students the opportunity to view the virtual instrument displays in real-time and have the ability to interact with the experiment. The first experiment to be developed was based on a SpectraQuest vibration simulator. Faults in the system were detected and diagnosed using data based techniques taught in the class.

4.0 RESULTS:

The newly offered distance education programs are in demand by nuclear engineering professionals. The distance students enjoy the convenience and flexibility offered by the CyberClass delivery system. In fact, the University of Tennessee was selected by Knolls Atomic Power Laboratory (KAPL) to be their NE distance education provider. Over 12 other NE programs submitted proposals to KAPL and the UT program was selected for a variety of reasons including the flexibility of the program (e.g., requiring math, allowing non-NE engineering courses), the retention of a research requirement in the DE program, and the interactive CyberClass delivery technology.

The demand is best shown through recent enrollment figures: the 2001 Fall semester figures show that the new distance education programs increased UT nuclear engineering graduate student enrollment by 25%. These figures reflect demand for the MS program because the Certificate programs do not officially begin until Fall 2002.

5.0 CONCLUSIONS:

The University of Tennessee's Nuclear Engineering Department has made a commitment to offer distance-based graduate programs to make nuclear engineering education more accessible to students throughout the U.S. and around the world. The use of information technology such as Centra's virtual classroom has made this endeavor practical without sacrificing the interactivity or quality of the learning experience. As these technologies mature, and as the UTNE faculty becomes more experienced in their usage, it is expected that the distance segment of NE graduate education will continue to grow.

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