A Brief History of Graduate Distance Education in Nuclear Engineering at Penn State University

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The Pennsylvania State University Nuclear Engineering Distance Education Program has a twenty year history of providing graduate level distance education in Nuclear Engineering. The Distance Education Program was initiated as a specific program which was developed for the Westinghouse Energy Systems Divisions in Pittsburgh. In 1983, Carnegie-Mellon University (CMU) decided to terminate its small Nuclear Engineering Program. Up until that time, Westinghouse employees could enroll at CMU for graduate classes in Nuclear Engineering as well as other engineering disciplines and could obtain a masters degree or if desired, could continue for a Ph.D. degree. This was very attractive to full time employees at the different divisions of Westinghouse and other nuclear related companies in the Pittsburgh area. However, when CMU ended the Nuclear Engineering portion of their engineering program, there was no local university which offered Nuclear Engineering courses. The University of Pittsburgh did not have program of study in Nuclear Engineering.

Westinghouse management was concerned about the lack of a graduate program in Nuclear Engineering in the Pittsburgh area for its employees. They believed that not having a graduate program in Nuclear Engineering would hinder hiring of new employees as well as limiting the development of all employees in the different areas of Nuclear Engineering. In 1986, Westinghouse approached The Pennsylvania State University, at University Park, PA to investigate if a program could be established at Westinghouse with Penn State Professors coming to Westinghouse to teach graduate classes in Nuclear Engineering. The University Park campus of Penn State is approximately 120 miles east of the Westinghouse Energy Center in Monroeville, PA so commuting between locations was possible if a suitable schedule could be developed. Dr. Warren Witzig, former Head of the Nuclear Engineering Department at Penn State worked with Westinghouse to establish a distance education program which would lead to a Masters of Engineering (MEng) degree in Nuclear Engineering. The first offering of the program in Nuclear Engineering began in the fall of 1986 and continued for approximately four years with courses offered each semester. Selective courses were taught by Penn State approved Westinghouse employees that had been teaching part-time in CMU's Nuclear Engineering Program and at the University of Pittsburgh. However, the majority of courses were taught by the Penn State University Park Professors on site at the Westinghouse Energy Center.

To receive a MEng degree, the distance students had to complete 27 credits of graduate level courses and a three credit scholarly paper. The scholarly paper could be an extension of a work related assignment that is more fully described and discussed. The scholarly paper was less than a typical MS thesis, but more than just a term paper and gave the student the

opportunity to expand upon a particular technical assignment from their work place or to undertake a specific project of interest. The program was administrated by Penn State and the students were formally admitted to the graduate school. Students could transfer up to nine credits of approved graduate work from other institutions into this program toward their degree. Penn State faculty would review and approve these transfer courses. Each student had a Penn State faculty advisor as well as a Westinghouse mentor who helped keep the student on track as well as to help with the scholarly paper.

The initial program was judged to be a success since over 50% of the students that finished the first year eventually graduated. The biggest problem was getting the students to complete their scholarly paper. Taking courses forced a degree of discipline on the students. However, writing the scholarly paper required significant self-discipline and after four years of courses, many students did not seem to have the energy to complete the paper in spite of the urgings of the faculty and the Westinghouse mentors.

In 1993, Westinghouse again identified a need for graduate education in Nuclear Engineering for its employees. In this case the audience was broadened and employees from the Bettis Atomic Power Laboratory and the Duquesne Light Company in Pittsburgh were also invited to participate. There were several different features of this second program. A professor from Carnegie-Mellon University was asked to teach two semesters of applied mathematics course, as part of the program, at the Penn State Monroeville location. This was the same course that this professor offered at CMU but by teaching it at the Penn State Monroeville location, the students did not have to commute to CMU. Penn State also developed some newer, more applied courses that were of interest to Westinghouse such as “Corrosion and Degrading of Reactor Materials” (now NucE 523), “Reactor Core Sub-Channel Analysis” (Now NucE 597B), Nuclear Reactor Safety (NucE 597D), and “Mechanical Engineering Aspects of Nuclear Engineering”. Most of these courses were developed by the Penn State faculty in collaboration with instructors from Westinghouse. Also, true distance education utilized two-way video conferencing and video taping. However, most of the classes were taught live at Westinghouse. Again, the graduation rate was approximately 50% with the scholarly paper still being a difficult hurdle for the students to complete.

In 2002 Penn State began the third offering of distance education in Nuclear Engineering. The current program is being taught to employees of Westinghouse Electric Company, Bettis Atomic Power Laboratory, and the Knolls Atomic Power Laboratory and the Navy. Most of the courses are conducted as live, two-way video and audio offerings and are regularly scheduled graduate courses with University Park resident students as part of the audience as shown in Figures 1a and 1b. The courses are delivered via multi-site interactive video-conferencing over Internet Protocol (IP) and Integrated Services Digital Network (ISDN). The courses are also available to all students in other formats such as live or on-demand streaming video, VHS tape, CD, or DVD depending on the specific student needs. Class materials are posted and distributed using the Penn State ANGEL web site which all enrolled students can access. ANGEL is the Penn State Course Management System and is a secured site in which both video and course materials can be accessed by registered students. Synchronous interaction is

facilitated with questions asked and discussed by both the resident and distance students during the live interactive lectures. Interactions with the instructor are also maintained via ANGEL threaded discussions, email and telephone.

In the Penn State Nuclear Engineering Program, the distance students are fully integrated into the resident graduate classes. Everyone has the same homework and project assignments, as well as the same examinations. The class time is adjusted to more easily accommodate the distance students with the classes being held typically from 5 to 7 pm on Mondays and Wednesdays EST. While this is a slight burden on the resident students, they have adjusted to this time frame. Students that cannot attend a lecture due to job related travel (either resident or distance students) can view the lectures via streaming video which is accessible on the ANGEL course site either live or following the live lecture. This capability makes the program particularly attractive to the distance students that have significant demands on their time and to the resident students who can also easily review a lecture to clarify specific points.

Most of the engineers that work in the nuclear industry are not engineers that graduated from a Nuclear Engineering Program. There are Mechanical, Chemical, Electrical engineers as well as Physics, Chemistry, and Engineering Science majors working and contributing to the development, design, operation, and regulation of nuclear power. Individuals with these degrees have also expressed an interest in a obtaining a graduate degree in Nuclear Engineering or the ability to take specific Nuclear Engineering courses to aid them in their personal development and profession. The main weakness that the non-nuclear engineering degree students have is the lack of applied courses in Atomic and Nuclear Physics as well as Nuclear Reactor Theory. These courses are typically taught in the junior and senior years of a Nuclear Engineering BS Program.

To make the Penn State Graduate Nuclear Engineering Distance Program attractive to students who do **not** have a BS degree in Nuclear Engineering, but are interested in an advanced degree in Nuclear Engineering, Penn State developed a three credit “ramp” course which compresses atomic and nuclear physics and reactor theory together, at the graduate level, to prepare the students for future nuclear engineering courses. This is also the same course that is taught to resident, non-nuclear engineering students that are entering the graduate nuclear engineering program at University Park. This course is typically taught the summer before the first full semester of graduate school. We have developed this course into a structured, distance learning course, which can be offered to both resident and distance students at any time during the year. Students can take the course at their pace, during the regular summer semester (15 weeks). There is a professor in charge as well as a grader which students will interact and correspond with during the course offering. We have had incoming resident students in South Africa, China, and France as well as at different locations within the US take this course before they arrive at University Park. We have had distance students also take this course over the summer before they enroll in the other distance graduate courses in Nuclear Engineering.

The outline and content for this course is given in Table 1 and the text books are “Introduction to Nuclear Engineering” by J.R. Lamarsh and A.J. Baratta; portions of

"Nuclear Reactor Analysis" by J.J. Duderstadt and L.J. Hamilton and "Nuclear Reactor Physics" by W.M. Stacey. While the course content can not be as inclusive as the traditional courses in the Nuclear Engineering program, this course does give the student sufficient information and background such that he or she can proceed to the other graduate level courses with confidence. The students are required to use workstations and or PC computers for their homework assignments.

Table 1

Nuclear Engineering 497A (RAMP)
Introduction to Nuclear Engineering

Class Topics Covered

1. Introduction: Role of Nuclear Engineering
2. Atomic and Nuclear Physics
3. Interaction of Radiation with Matter
4. Nuclear Reactors and Nuclear Power
5. Neutron Diffusion and Moderation
6. Nuclear Reactor Theory
7. Reactor Kinetics
8. Review

Penn State does have a requirement for all graduate students that do not have a BS degree in Nuclear Engineering that they must complete a nuclear laboratory experience. The idea is to sensitize the student to working and understanding radiation sources. As part of the first two distance MEng offerings, Penn State also offered a nuclear laboratory experience for the non-nuclear BS distance students. This course was patterned after the undergraduate laboratory courses offered at the University Park campus. The course was offered in the summer and the distance students would drive to the University Park campus early on Saturdays and perform experiments both at the reactor and in the counting laboratories as teams. The students would then complete the data analysis and the laboratory report write-ups during the week and hand in the reports the following Saturday. This was very intensive and un-popular with the distance students since it was very disruptive to their work week, reduced significantly their weekend time with their family and disrupted their vacation time. The result was that several of the students simply dropped out of the program, never to return.

When Penn State met with Westinghouse to discuss the 2002 program, we were considering dropping the requirement for the laboratory experience. However, it was Westinghouse that insisted that a laboratory experience be integrated into the distance program for their employees that did not have a BS degree in Nuclear Engineering. Westinghouse did not want any difference between the distance graduate program and the resident graduate program. Therefore, they requested that Penn State develop an alternative laboratory experience that would be less of a burden on distance students but would still give the non-nuclear engineering BS students some working experience with radiation and operation of a real reactor.

The approach that was developed was to have the non nuclear engineering BS distance students spend a long weekend at University Park. The text book was mailed to the students several weeks before the classes and the students were instructed to complete the readings before the laboratory sessions were held. The text book used was "Radiation Detection Measurements", 3rd edition, by G.F. Knolls. The distance students would come to the University Park

campus on a Wednesday night and classes would be held all day Thursday, Friday and one-half a day on Saturday. The students would then leave for home Saturday afternoon. The students, working as teams, performed several experiments using radioactive sources, radiation detection equipment, and the Penn State TRIGA reactor. While the students participated and performed the experiments, reduced and analyzed the data, no formal reporting was required. The idea is to sensitize the students to a radiation environment and have them gain an understanding for radiation measurement and detection. This achieved the goals specifically requested by Westinghouse. The student's response to the laboratory course was excellent. They enjoyed the on campus experience and the series of compressed laboratory sessions. While this approach was easy, due to the near proximity of Westinghouse to Penn State such that the students could car-pool, a similar approach would also work for students excepting that the travel costs could be higher. The students were responsible for their room, board and travel costs, however, lunches were provided by the program.

As mentioned earlier, the requirements for the MEng degree is 27 credits of courses and a three credit scholarly paper which is reviewed and approved by both a sponsoring organization mentor, such as Westinghouse, and a Penn State faculty mentor. We have encouraged students to expand upon an assignment at their work place and develop the assignment into a more complete analysis for the scholarly paper. In the previous distance programs several students took the advice and did expand upon a specific topic from their work place and developed this into a very acceptable scholarly paper. Other students, however, had a particular topic of interest which they want to investigate in more depth and the scholarly paper afforded them this opportunity. Some of the scholarly papers which were completed by the students were equal to a master's thesis, particularly those that performed detailed research and or analysis of experimental data. Many of the MEng scholarly papers lead to a technical publication. Examples of completed MEng paper topics from the previous distance programs are given in Table 2.

Table 2

Examples of MengScholarly Papers

Verification of the Beaver Valley Transient Analysis using COBRA-IV PC Code

Separation of diversion Crossflow effects and Thermal Diffusion Effects in COVRA-IV PC

Application of AP600 NOTRUMP Models to Standard Westinghouse Plants for SBLOCA

Improved PWR Set-Point Methodology

An Investigation of the Application of Selected Pool Boiling Heat Transfer Correlations to the AP600 Passive Residual Heat Removal System

Development of a Flow Regime Dependent Correlation for Determining Frictional Pressure Drop in a Vertical Two-phase Flow

Table 3 shows the current program that started in 2002. Currently there are 50 distance students enrolled in this program and with the increased hiring at Westinghouse, Bettis and Knolls Laboratories, there is interest in continuing to run the program each semester. As indicated earlier, in previous distance Penn State Nuclear Engineering programs, the

graduation rate was approximately 50%. With the improvements we have made in the current curriculum we expect a higher graduation percentage with this program offering.

Figure 1a. Resident students at University Park in a distance classroom.

Figure 1b. Distance students at Westinghouse in the same class as above

Table 3

Nuclear Engineering Program - Tentative Schedule of Courses					
Year	**2002**	**2003**	**2004**	**2005**	**2006**
Sp		**NucE 428** Nuclear Waste (3 cr) (Scheetz)	**NucE 521** Neutron Transport Theory (3 cr) (Azmy)	**NucE 597D** Nuclear Reactor Safety (3 cr) (Hochreiter) ---------- **NucE 420** Radiological Safety (3 cr) (Brenizer)	**NucE 597B** Subchannel Reactor Analysis (3 cr) (Hochreiter) ------- **NucE 597K** Reactor Kinetics (3 cr) (Ivanov)
Su	**NucE 297/497** Ramp Course (3 cr) (Ivanov)	**NucE 497C** Radiation Measurement (1 cr) (Brenizer)	**NucE 530** Parallel/Vector Algorithms for Scientific Application (3 cr) (Azmy)	**NucE 497A** Fundamentals of Nuclear Engr. (3 cr) (Ivanov) --------- **ME NucE 460** Reliability Concepts in Design (3 cr) (Kurtz)	**NucE 497A** Fundamentals of Nuclear Engr. (3 cr) (Ivanov)
FA	**NucE 501** Reactor Engineering (3 cr) (Hochreiter)	**NucE 523** Environmental Degradation of Materials in a Nuclear Power Plant (3 cr) (Motta/Macdonald) ---------- **NucE 403** Advanced Reactor Design (3 cr) (Azmy)	**ME 515** Two Phase Flow and Heat Transfer (3 cr) (Hochreiter) ------- **NucE 408** Radiation Shielding (3 Cr) (Azmy)	**NucE 525** Monte Carlo Methods (3 cr) (Ivanov) ---------- **NucE 512** Fuel Management (3 cr) (Ivanov) ---------- **NucE 403** Advanced Reactor Design (3 cr) (Azmy)	**NucE 408** Radiation Shielding (3 Cr) (Azmy) ---------- **NucE 501** Reactor Engineering (3 cr) (Hochreiter)