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DEVELOPMENT AND TEAM-TEACHING OF "COMPUTERS AND NUCLEAR ENERGY" COURSE FOR NON-NUCLEAR ENGINEERING STUDENTS

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INTRODUCTION

This paper reports an interdisciplinary nuclear safety course development project and the experience and assessment of the team-teaching of the course comprised of the project investigators at Howard University and the U. S. Nuclear Regulatory Commission (NRC) guest speakers. The new course was developed around the safety issues of computer controls in nuclear power generation. The team-teaching model allowed an institution without nuclear engineering program to offer nuclear safety courses to engineering students. The first offering of the course resulted in very positive response from students and, with revision and improvement from the assessment result, the second offering is undergoing.

TEAM-TEACHING MODEL

The rapid adoption of computer control systems for nuclear power plants has resulted in the reliability of computer hardware and software becoming an important component of nuclear plant design, operation and maintenance. The need for safe and reliable of computer based control systems has created new and greater concerns that have not been experienced in the age of analog control, because the failure of a single component, whether it be a control logic or a subroutine in a code, could disable major functions of the system and cripple the whole plant. This new situation requires a timely supply of capable engineers who can deal with the new issues of safety and reliability of computer control systems in nuclear plant operation. However, there is a challenge of teaching an interdisciplinary nuclear course to non-nuclear students, especially in an institution with no nuclear engineering program. To meet the challenge, a new teaching model is needed to develop a course which "diversifies and adds excitement to the nuclear field" [1].

A new course development project was conducted sponsored by NRC which aimed to expose non-nuclear minority engineering students to the nuclear engineering field, by utilizing a team-teaching model [2]. The lecture was organized, comprised of the project investigators to teach computer safety and the nuclear experts to nuclear safety, and a new course was offered with the team-teaching model.

NEW COURSE DEVELOPMENT

The new course was developed with emphasis on defense-in-depth concept and hardware and software diversity relevant to digital instrumentation and control (I&C). Specifically, the following five areas were focused:

Digital I&C: The majority of I&C systems in today's nuclear plants are beginning to apply advanced I&C technology in all aspects of operation and maintenance.

Software Errors: A number of software errors have been found in operating nuclear plant software, and it is a known fact that the failure due to software errors occurs as often as hardware failures and that software errors tend to be difficult to prevent because they may occur only when an unusual set of inputs exists.

Computer Technology and Common Mode Failure: Computer control system faces safety issues in that common mode failures may fail even redundant safety systems compromising safety functions [3]. Therefore, the system requires not only redundancy but also diversification strategies.

Defense-in-Depth and Diversity (D3): All safety activities are subject to layers of overlapping provisions so that if a failure occurred it would be compensated for or corrected without causing harm to the entire system. The defense-in-depth concept ensures that no single failure could lead to a system failure. In practice, multiple versions of software of different algorithms can be written for the same function as much as hardware of completely different architectures and designs can be employed [4].

Hardware Diversity Kit: The hardware diversity kit is composed of a nuclear reactor event scenario generator and a set of diverse architectural hardware which individually responds to the scenarios. For coding each of the platforms, it requires to use different behavioral requirements for the same function for the scenario.

FIRST COURSE OFFERING EXPERINCE

The new course, officially numbered and titled as "EECE499 Computers and Nuclear Energy" at Howard University, was offered for the first time in fall 2011 for all engineering students. The course was conducted with

the following weekly schedule covering the two safety subjects simultaneously.

Week 1: Introduction to the new class.
Week 2: Computers and risks; and introduction to nuclear reactors.
Week 3: Myths on correctness; and digital I&C.
Week 4: Software myths; and security and safeguards.
Week 5: Software reliability in safety-critical systems; and nuclear criticality and nuclear engineering.
Week 6: Defense in depth; and power uprates.
Week 7: Diversity; and licensing processes.
Week 8: Hardware diversity kit with assignment on diversity in everyday life, and power generation.
Week 9: Standards of safety-critical systems; and cyber-security.
Week 10: Software reliability; and severe accidents.
Week 11: Tour of the center; and Fukushima accident.
Week 12: Safety-critical computer systems; and new modular reactors.
Week 13: Hardware diversity lab 1.
Week 14: Hardware diversity lab 2.
Week 15: Final class and summary

A total of 26 engineering students, 19 undergraduate (of electrical, computer, and chemical engineering) and 7 graduate (of electrical engineering) levels, took the class. A survey was conducted for the students to measure their perception of the course. Overall, the students expressed very positive attitudes in taking the course. They rated the course quite favorably in their (a)understanding in computer mistakes and errors (b) understanding nuclear energy and safety, (c) understanding the use of computer in nuclear area, (d) interest in safety-critical computer system, and (e) achieving what they expected.

CONCLUSIONS

This paper described an NRC sponsored project of developing and teaching an interdisciplinary nuclear course for non-nuclear engineering students at Howard University by applying a team-teaching model to cover two subjects in safety concerns: computer control and nuclear energy generation. The majority of students of 26 agreed that the course met their expectation and increased their knowledge and understanding of the computer and nuclear safety subjects. The project, further enhanced and continued, would meet the demand not only for training students but also eventually for diversifying workforce in computer and nuclear safety.

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