Development of a Problem-Based Undergraduate Nuclear Course to Strengthen Math Skills in Support of the US Nuclear Workforce

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INTRODUCTION

Linn State Technical College (LSTC) and the University of Missouri (MU) are developing a college freshman level nuclear technology course based in a problem-centered learning environment. This project is resulting in an industry-driven, web-based course for immediate implementation by LSTC and made available for schools across the country with post-secondary programs in nuclear technology and related fields. Additionally, the course will be piloted as a dual-credit college-level course available to qualified high school students, delivered at an area vocational technical school as part of a pre-engineering curriculum.

Since solid skills in problem solving and mathematics related to nuclear science are vital to nuclear safety in the commercial nuclear energy industry and other nuclear sectors, our goal is to develop a standardized curriculum to teach mathematical concepts essential to employment success in the demanding nuclear industry. Course content includes basic nuclear theory, with the overall curriculum benchmarked against INPO-ACAD and DOE fundamental training requirements. For students interested in further training and/or a career as a nuclear technician, the course will provide an excellent background for two-year associate's education in radiation protection, instrumentation and controls, quality control, reactor operations, and other nuclear fields. We also envision the course will aid in recruiting students into four-year engineering curricula related to nuclear workforce needs.

THE NEED

The "Nuclear Math" course being developed addresses a need consistently identified by academicians at two- and four-year institutions and nuclear industry employers for workers with stronger math skills (a competency for essentially every job grade in the nuclear workforce). The United States is facing an overall aging workforce and accelerating retirements that directly contribute to the shrinking number of technical and highly-skilled workers available for employment, particularly in the nuclear industry. Too few high school graduates are fully prepared for the rigors of postsecondary training and education, especially in the areas of math and science.

The National Mathematics Advisory Panel [1] reported that only 23% of high school seniors are considered proficient in math, and that there is a vast and growing demand for remedial mathematics education among students arriving in four-year and community colleges. Among other findings, the use of instructional software and other technologies has generally shown

positive effects on students' performance when compared with instruction that does not incorporate technology. Similarly, a "Southeast Work Force White Paper" [2] stated, "A 2004 survey by the Utility Business Education Coalition found that half of all applicants for entry-level skilled trades positions lacked the academic and basic skills required for employment. For example, one industry training manager reported that only half of recent applicants passed mandatory screening tests, and of those, only half passed pre-employment skills test."

During the four years that LSTC and MU have been collaborating to matriculate Radiation Protection Technicians, entering students have consistently been limited by their ability to problem solve, perform basic mathematic computations and apply mathematic principles to real world problems. This deficiency has limited their ability to progress through the curriculum without remedial mentoring and/or coursework, and has been the primary cause for approximately a 20% dropout rate. This has created a need for *ad hoc*, mathematics tutoring by the instructor, impeding the progress of all students in the curriculum. More limiting is the number of students who decide not to enter these academic programs because they are fearful of the math content involved in the curriculum. This same unpreparedness negatively affects the number of applicants that have the capability to successfully complete on-the-job training or apprenticeship programs that require good math and problem-solving skills.

COURSE DEVELOPMENT

The math-based course will reinforce and build on the students' mathematics background and skills through problem solving for applied settings specific to the nuclear industry. As the student continues developing problem solving and critical thinking skills, they will also increase their knowledge and conceptual understanding of basic nuclear theory, along with interest in the nuclear field.

Table 1 is our preliminary course outline, which links the basic math skills identified by the College Level Examination Program (CLEP - a series of examinations that demonstrate college-level achievement in various disciplines) to the nuclear content typically taught in an introductory Nuclear Science or Radiation Fundamentals course.

The class is designed to be delivered in seven units of instruction, each containing nuclear theory/calculations applicable to the math objectives of that unit. Additionally, the accompanying server and website have been established. The course development team reviewed job competencies used in our ongoing Nuclear Technology curriculum development activities, as well as the new "Uniform Curriculum Guide for Nuclear Power Plant Technician, Maintenance, and Nonlicensed Operations Personnel Associate Degree Programs" [3].

We are designing and developing electronic curriculum resources and a printed teacher's manual to support course implementation. The website - http://netwcenter.rnet.missouri.edu/math/ - is designed to accommodate the interactive, problem-centered curriculum, with separate and distinct capabilities for the students and instructors. (For demonstration purposes, Username: userone Password: userone)

CONCLUSIONS

The expected impact of this project will be increased success rates for students pursuing nuclear technology education and an increased pool of graduates qualified to fill highly skilled jobs in the nuclear workforce. Secondarily, this project will generate an increased interest in younger students to pursue nuclear-related careers.

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REFERENCES

1. "The Final Report of the National Mathematics Advisory Panel," March 2008, U.S. Department of Education; www.**ed.gov**/about/bdscomm/list/math**panel**/report/final-report.pdf
2. "Southeast Work Force White Paper", Department of Labor Energy Skilled Trades Summit, Biloxi, MS (August 27-28, 2007).
3. "Uniform Curriculum Guide for Nuclear Power Plant Technician, Maintenance, and Nonlicensed Operations Personnel Associate Degree Programs," ACAD 08-006 (Preliminary), September 2008, National Academy for Nuclear Training.

Table I - Preliminary Nuclear Math Course Outline

Core Concept	Math Skill	Nuclear Context
Algebraic Operations	Operations with Algebraic Expressions	Calculating external dose
		Calculating dose as a function of exposure time
		Calculating decay from “powers of two” equation
		Exposure, dose and dose equivalent relationships
		Calculating internal dose
		Calculating detector dead-time corrections
		Calculating detector efficiency and sample activity
	Operations with Exponentials	Calculating decay
		Calculating gamma-ray attenuation
		Calculating integrated internal dose
	Properties of Logarithms	Fitting radioactive decay
		Calculating activation
Equations	Exponential Equations	Parent-daughter relationships
	Logarithmic Equations	Calculating half-life from experimental data
Functions	Graphical Representations	Plotting radioactive decay
		Plotting gamma-ray attenuation
		Estimating range from experimental data
	Inverse Functions	Dose vs distance from source
	Statistics	Calculating counting statistics
		Propagation of statistics