Safeguards Education Outreach at Texas A&M University

David "Grant" Ford Jr, William S. Charlton, Kelley Ragusa
Texas A&M University, College Station, TX 77843-3133 USA

Abstract:

The Nuclear Security Science and Policy Institute (NSSPI) at Texas A&M University (TAMU) has established a Master of Science in Nuclear Engineering that focuses primarily on Nuclear Safeguards, Security, and Nonproliferation. This program has been effective at educating the next generation of safeguards experts in nuclear engineering. However, the safeguards community must increase its capability to educate a broader audience of nuclear engineers, such as those in the commercial nuclear power sector, in addition to recruiting and educating outside of nuclear engineering departments. As a result, NSSPI has already developed and taught a 1-hour lecture to all incoming freshman in the TAMU Nuclear Engineering program. In addition to this, lectures are being prepared that will be given in the senior level design course at both the undergraduate and graduate level. These lectures are a first step toward developing a lecture series that may be given in all the disciplines applicable to safeguards such as mathematics, political science, physics, other engineering disciplines, etc. Additional information may be required for this outreach such as reading materials or videos to provide background information, and post lecture exercises as a homework assignment or mechanism for engaging the professors of the other disciplines.

Keywords: nuclear safeguards, security, and non-proliferation education, distance education

1. Introduction

The constantly evolving nature of global terrorism requires the nuclear community to address a shifting landscape of threats. Possible nuclear terrorism scenarios are many and varied, consisting of the use of radiological dispersal devices (RDD), sabotage of commercial nuclear facilities, theft of weapons useable material, theft of nuclear devices, etc. These threats have been made all too real by the many times senior Al Qaeda leadership has expressed interest in nuclear attacks [1], and attacks on existing nuclear targets [2]. The threat of nuclear terrorism has also been acknowledged by President Barack Obama at the plenary meeting of the Global Initiative to Combat Nuclear Terrorism: "*There is no graver danger to global security than the threat of nuclear terrorism, and no more immediate task for the international community than to address that threat.*" [3]

In order to effectively address these threats, we must first ensure that the nuclear safeguards community remains robust. The need for future nuclear workers, in all related fields, has been expressed on a global scale. This workforce will be required to address many concerns, from replacing the aging workforce in existing capacities, to meeting the growth needs of the expanding nuclear community. Simply meeting the requirements for the aging workforce will be a substantial challenge. According to the Nuclear Regulatory Commission (NRC), nearly half of the nuclear industry workforce is over the age of 47 [4]. This equates to the industry possibly losing up to 40% of its workforce in the next five years. Unfortunately, the demographics in the safeguards community are even worse, particularly in the U.S. national laboratories.

In order to address the need to both replace the aging safeguards workforce and expand existing capacity to meet the changing threat environment, it is essential that the community:

- Manage existing safeguards knowledge;
- Redirect existing nuclear workforce personnel to the safeguards area;
- Educate the next generation of safeguards specialists;
- Increase the knowledge of existing technical disciplines on safeguards issues and core needs; and
- Increase public awareness of safeguards and nonproliferation issues.

The Nuclear Security Science & Policy Institute (NSSPI) at Texas A&M University (TAMU) is addressing many of these concerns.

2. Education Outreach

NSSPI has already successfully created a Master of Science degree program within the Nuclear Engineering department at TAMU that is designed to educate graduate students in the field of international nuclear safeguards and security. This program has been successful in producing young professionals that have found employment throughout the U.S. nuclear community. However, there are many other disciplines that must be employed in the safeguards community for it to be effective. While a comprehensive nuclear engineering safeguards education is the logical first step, all other requisite disciplines must be addressed as well. The most notable disciplines employed in safeguards are:

- Physicists
- Chemists
- Mathematicians
- Statisticians
- Computer Scientists
- Political Scientists
- International Affairs Experts
- Lawyers

- Law Enforcement/Security Specialist
- Nuclear Engineers
- Mechanical Engineers
- Electrical Engineers
- Chemical Engineers
- Industrial Engineers
- Environmental Engineers

It should be noted that Nuclear Engineering must still be included in this list. While TAMU already offers a Master of Science in this area (with assistance from NSSPI), the majority of students in any nuclear engineering department will still take the typical nuclear engineering course load focusing on commercial nuclear power applications.

All of the disciplines listed above should be made aware of nuclear safeguards as a profession and employment opportunity, as well as our operating procedures and the importance of safeguards as a field. This is crucial to the realization of an effective safeguards culture in the U.S. As the safety culture has already accomplished, the nuclear community as a whole must realize that safeguards is an integral part to ensuring that nuclear power remains available to future generations.

2.1 Existing Courses at TAMU

Outreach to students outside the NSSPI program has already begun. As freshmen in the nuclear engineering department, all students are required to take NUEN 101: Principles of Nuclear Engineering. This course provides an introduction to nuclear engineering including global and national energy requirements, radioactivity, radiation protection, and fission and fusion reactor concepts. It consists of a semester-long series of 1-hour lectures that now includes an introductory segment on safeguards, arms control, and non-proliferation. The objective of this is that as students progress through their undergraduate career at TAMU, they are capable of putting all of the knowledge they gain about commercial applications of nuclear engineering within the context of how safeguards may be applied and affect the overall system.

A senior level undergraduate course is also being offered as NUEN489: Nuclear Nonproliferation and Arms Control. The course description is as follows:

> “This course will study the technologies associated with the proliferation of nuclear weapons and the attempts to halt this proliferation. Topics will include the history of nuclear weapons development, descriptions and effects of weapons of mass destruction, nuclear material safeguards, protection of nuclear materials, proliferation resistance, proliferation pathways in the nuclear fuel cycle, the search for undeclared activities, and nuclear terrorism.”

The objectives of this course include Safeguards Systems and Technologies. This course ensures that seniors who elect to enroll will be exposed to safeguards as a field as they are making their decisions concerning future employment or graduate studies.

Additionally, this course is much more in depth than the initial introduction they received as freshman.

AT TAMU, the NSSPI-developed coursework for the Master of Science is also increasingly being taken by the general graduate nuclear engineering population. While their specific area of study may not be directly related to nuclear safeguards, enough of them recognize safeguards as an exciting field and have elected to take NSSPI courses as electives. This alone is a very positive indication for our field.

2.2 Future Coursework

TAMU already offers a course entitled NUEN410: The Design of Nuclear Reactors. The course addresses the application of reactor theory and other engineering disciplines in fundamental and practical design of nuclear reactor systems for power applications. A short series of lectures is currently being developed that will ideally be introduced to expose students taking this course to existing safeguards systems and safeguards by design for next generation reactor systems. This will serve to reinforce safeguards as an integral part to the reactor systems they are studying. Additionally, this will instill a positive safeguards culture in future members of the larger nuclear community.

There is a similar class taught at the graduate level that will eventually be included as well. The lecture material will be adapted to be applicable to the specific systems being studied.

2.3 Nuclear Safeguards Education Portal (NSEP)

The Nuclear Safeguards Education Portal (NSEP) was launched in the spring of 2009 as an effort to provide introductory information to summer interns interested in safeguards. The Department of Energy, through the Next Generation Safeguards Initiative (NGSI), funded a large number of students from across the country to participate in internships across the laboratory complex. These students all participated in safeguards education initiatives being taught as summer courses. However, the participating students were from a wide variety of backgrounds with varying degrees of technical expertise. Previous summer efforts were hampered by this fact. Students with technical backgrounds (such as nuclear engineering) were underutilized during the significant introductory sessions necessary for non-technical students. As a result, NGSI provided funding for the development of NSEP. This year, these courses were developed as required modules for students unfamiliar with the technical aspects of safeguards. Students from all over the country participated with a large degree of success. The current modules are:

- Basic Nuclear and Atomic Physics
- The Nuclear Fuel Cycle
- Basics of Radiation Detection

While all of these modules were specifically designed for use in the summer seminars, they ultimately will serve to provide educational resources for students with an interest in nuclear safeguards and the security of nuclear materials anywhere in the world. All the current modules are available to anybody regardless of whether or not they are enrolled at Texas A&M University (TAMU).

The primary goal of NSEP is to focus on technical education in the area of nuclear safeguards. This will serve to develop individuals with the technical skills needed to help design and implement systems and technologies for securing nuclear materials at commercial nuclear facilities and detecting covert nuclear activities.

The modules are intended to be completed in a few hours. They consist of reading materials, supporting video from professors at TAMU and subject matter experts from the national labs and industry (where appropriate), along with links to additional resources. In the future, all modules will also contain self assessments to test the students understanding of the material. The online, asynchronous nature of the modules provides students with the opportunity to complete the module at their own pace. This is ideal for students engaging in continuing education efforts, off-site students, etc. However, it is important to point out that this type of education is not suitable for all topics. There are many instances in which asynchronous distance learning can be a very powerful tool for educating a far reaching audience but only when used properly. Certain subjects must be taught in residence at an educational institution. This distinction is important, and the temptation to reach a larger audience, regardless of effectiveness, must be resisted. Effective safeguards education outreach must be the goal.

2.3.1 Basic Nuclear and Atomic Physics

Prerequisites: Students taking this module should have a working knowledge of basic algebra

Learning Objectives: Students completing this module should be able to describe the structure of the atom, the constituents of the nucleus, and different types of radiation. The student should be able to give definitions of basic nuclear physics terms and units of measure. The student should be able to use a period table and chart of the nuclides to identify specific isotopes and elements and their properties. The student should be able to explain the interactions of radiation with matter and the physics of nuclear fission. The student should be able to complete simple calculations using energy and mass relationships, atomic density, and radioactive decay.

Outline: This module consists of seven sections:

1. Energy and mass relationships
2. Atomic structure
3. Periodic table and chart of the nuclides
4. Nuclear Stability

5. Fission
6. Particle and Electromagnetic Radiation
7. Radioactivity and Radiation

2.3.2 The Nuclear Fuel Cycle

Prerequisites: Students taking this module should have a working knowledge of basic algebra and a basic understanding of physics and chemistry.

Learning Objectives: In this module, students will be introduced to the basic nuclear fuel cycle including the different processes involved and the basic physics of the fundamental components. Students completing this module should be able to describe all of the steps in military and civilian nuclear fuel cycles and be able to perform basic analysis of known fuel cycles. Students should be able to describe how fuel cycle facilities operate and the materials used and produced by those facilities.

Outline: This module consists of four sections:

1. Introduction to the Commercial Nuclear Fuel Cycle
2. The Front End of the Nuclear Fuel Cycle
3. Fuel Irradiation and Fuel Storage
4. The Back End of the Nuclear Fuel Cycle

2.3.3 Basics of Radiation Detection

Prerequisites: Students taking this module should have a working knowledge of basic algebra and know what a neutron and gamma-ray are.

Learning Objectives: Students completing this module should be able to describe the physical mechanisms for detection of gamma and neutron radiation. They should also be able to identify and explain the general operation of gas-filled, scintillation, and semiconductor detectors.

Outline: This module consists of seven sections:

1. Introduction
2. Counting Statistics
3. Gas-Filled Detectors
4. Neutron Detectors
5. Gamma-Ray Spectroscopy
6. Semiconductor Detectors
7. Detector Lab

3 Conclusion

The existing Master of Science in Nuclear Safeguards at TAMU is providing young professionals the opportunity to become the next generation of safeguards experts, both domestically and internationally. This program is becoming increasingly popular with a constantly increasing student enrollment. Individual courses within this program are also becoming increasingly popular with students not associated with NSSPI or focusing in nuclear safeguards and nonproliferation issues. Additional efforts within the TAMU Nuclear Engineering department ensure that all graduates of the undergraduate program are aware of safeguards regardless of their future employment. This ensures that a positive safeguards culture is encouraged prior to students even entering the work force. Finally, students unassociated with TAMU and NSSPI have the opportunity to educate themselves and be introduced to safeguards as a profession and viable career path through NSEP.

4 References

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