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Educating the Next Generation of Nuclear Safeguards and Security Experts at TAMU

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ABSTRACT: The Nuclear Security Science and Policy Institute (NSSPI) has established a Nuclear Nonproliferation specialization for the Master of Science degree within the Nuclear Engineering Department at Texas A&M University (TAMU). Since 2004, twenty-eight students have received MS degrees in this area and over 200 (technical and policy) students have taken classes offered by NSSPI at TAMU. The model for educating safeguards and security experts is being changed at TAMU. Beyond conventional classroom lectures, NSSPI has developed alternative educational models based on practical experience, asynchronous learning portals, and virtual courses in both nuclear safeguards and nuclear security. Due to the experimental and practical past experiences of NSSPI staff and faculty, a heavy hands-on component has been implemented for TAMU nuclear engineering graduate students: hands-on education at Oak Ridge National Laboratory, visiting nuclear installations in other countries to discuss applied safeguards, and summer internships at several national laboratories. In an effort to disseminate basic nuclear education for professionals and students around the globe, NSSPI has developed a publically-available online resource that offers self-paced, independent course modules in basic safeguards and security education: the Nuclear Safeguards Education Portal. Another venture utilized by NSSPI is using a virtual TAMU campus to hold classes for students at a distance. NSSPI is building upon a successful academic program by embracing new educational means. This paper describes the current efforts NSSPI and TAMU have undertaken in strengthening the nuclear nonproliferation, safeguards and security human resource capacity domestically and internationally and the lessons learned from these efforts.

KEYWORDS: *nuclear; safeguards; security; education; university*

I. INTRODUCTION

It is in the general interests of mankind and the specific interests of the United States government to detect, prevent, and reverse the proliferation of weapons of mass destruction materials, technology, and expertise and control existing arms stockpiles. To help achieve this goal, Texas A&M University (TAMU) has been developing the next generation of nuclear nonproliferation and material safeguards experts through the Nuclear Security Science and Policy Institute (NSSPI) using technical and policy education. Since 2004, NSSPI has offered a Master's of Science degree with a Nuclear Nonproliferation Specialization within the Nuclear Engineering department (MS-NNP) at TAMU to satisfy the growing need of safeguards and security experts worldwide. During this period, TAMU has graduated 28 students with MS degrees with the nonproliferation specialization and educated more than 200 students via the courses taught at TAMU.

In light of the development of nuclear security science education at national laboratories around the world, a small number of universities have begun offering courses, certificates, and degrees in these areas to assist the new network of nuclear security experts. To complement the number of political and social science academic programs within this field, the TAMU program focused primarily on a technical orientation in the nuclear security sciences with policy as a supporting element to help students understand the policy implication of new technologies. Education of this kind is achievable only through a combination of theoretical and practical education curricula and a heavy focus on technical research on how to meet the expectations dictated by the policies of the safeguards and nonproliferation regimes. Furthermore, TAMU has joined with two other respected universities (Pennsylvania State University and the Massachusetts Institute of Technology) to develop a robust nuclear security education program that can be exchanged among the three universities and possibly shared to other academic institutes in the future.[1]

Independently, NSSPI and TAMU have implemented the MS-NNP program for the past five years and have seen a number of successes and learned a number of lessons. Various methods have been tried and some have continued to be utilized by the faculty in effectively teaching the various topics offered by the nuclear engineering department at TAMU. This program has converged into using the following program elements to provide an exceptional education experience:

1. Nuclear engineering core discipline courses to provide the fundamental technical background
2. Nonproliferation, safeguards, and security specific technical courses to provide technical details of direct relevance to the mission area
3. Elective courses to provide increased breadth of knowledge into several areas of application to the mission (e.g., courses on national security policy) or deep technical knowledge into a single area (e.g., a course on nuclear forensics inverse analyses)
4. Technical research applied specifically to the mission area
5. Practical experience via training sessions at national laboratories, summer internships at national laboratories, and visits to commercial fuel cycle facilities
6. Prerequisite course material via asynchronous distance learning modules
7. Course implementation via real-time, fully-immersive distance education via the 3D virtual world Second Life
8. Extracurricular learning opportunities via the TAMU student chapter of INMM

Details for these program elements will be presented in the subsequent sections of this paper after a brief overview is presented on the current status of the MS program.

II. CURRENT NONPROLIFERATION CURRICULUM AND EDUCATION AT TAMU

TAMU faculty and students have been active in the research fields of nuclear nonproliferation, nuclear material safeguards, and international security for many years. Activities have included scientific and engineering research projects with Los Alamos, Sandia, Oak Ridge, Lawrence Livermore, Savannah River, Idaho, and Pacific Northwest National Laboratories. Among others areas, research has included proliferation resistant nuclear fuel designs, proliferation resistance assessments for fuel cycles, nuclear material safeguards development and analysis, development of portal monitors for detecting the illicit trafficking of nuclear materials, modeling of nuclear smuggling routes, post-event nuclear material attribution, compilation of reactor data for international safeguards and safety purposes, and studying nuclear terrorism pathways.

Additionally, the MS-NNP program is based off the MS degree in Nuclear Engineering. Several courses rooted in nuclear engineering basics are included in the program for the belief that students should understand the grand scheme of how safeguards and nonproliferation is applied to the broader nuclear fuel cycle. This degree program develops a student's understanding in the area of global nuclear security through research and classroom activities which fosters their creativity in solving complex problems with a solid technical focus.

The degree program is designed as a 1½ to 2 year program consisting of nine formal courses. Of these formal courses, seven are required courses and two must be selected from a set of possible electives. As a Master of Science degree the students will also complete research of fundamental interest to the field and write a corresponding thesis detailing their research. The outline of the Master of Science in Nuclear Engineering with Nuclear Nonproliferation Specialization (MS- NNP) is shown in Table I.

Table 1. MS-NNP Degree Curriculum

	Course Title	**Credit Hours**
Fall Year 1	Nuclear Reactor Theory	3
	Radiation Detection and NM Measurement	3
	Nonproliferation and Arms Control	3
	Seminar in Nuclear Engineering	1
	Independent Study	2
Spring Year 1	Nuclear Radiation Shielding	3
	Nuclear Reactor Analysis and Experimentation	4
	Nuclear Fuel Cycles and Safeguards Systems	3
	Research	2
Fall Year 2	Critical Analysis of Nuclear Security Data	4
	Technical Elective	3
	Technical Elective	3
	Research	2

Elective courses are selected from a set of various courses offered in relevant areas and provided by other faculty elsewhere at TAMU including:
1. NUEN 489 Design of Nuclear Facility Security Systems (Nuclear Engineering Department)
2. CHEM 681 Radiochemistry and Nuclear Forensics (Chemistry Department)
3. MATH 644 Inverse Problems in Nuclear Forensics (Mathematics Department)
4. INTA 620 International Security (Bush School of Government and Public Service)
5. INTA 617 Deterrence (Bush School of Government and Public Service)
6. INTA 657 Terrorism in Today's World (Bush School of Government and Public Service)

These courses are intended to give the student's education a particular focus on several issues of interest to the field and provide some diversity for the student's degree program.

III. COURSE DESCRIPTIONS

In this section, a brief description of the required courses in this degree program is given. Additionally, in the last section, the current effort in developing a nuclear security education curriculum will be conveyed with the appropriate courses described. It should be noted that the design of this program was intended to build upon the general fundamentals of a nuclear engineering Master of Science degree. Thus, many of the courses are fundamental nuclear engineering courses which would exist to some degree within nearly any nuclear engineering program.

1. Current Curriculum

The MS-NNP program at TAMU currently consists of the following six courses[2]:

Nuclear Nonproliferation and Arms Control – This course gives a basic overview of topics learned in the degree program and introduces the student to the political and technological issues associated with nuclear nonproliferation. Topics studied include the history of arms control, descriptions and effects of weapons of mass destruction, details of various arms control treaties and efforts, international and domestic safeguards, proliferation resistance in the nuclear fuel cycle, nonproliferation strategies, treaty verification regimes, nuclear terrorism, and verifying the elimination of weapons programs. Students perform two simulation exercises based on a hypothetical global security scenario. These simulations require the student to synthesize content from throughout the course to generate and evaluate solutions to the proposed scenario.

Nuclear Reactor Theory – This course discusses fundamental nuclear reactor theory. It focuses on the physics of nuclear systems including neutron-nucleus interactions; neutron energy spectra; transport and diffusion theory; multi-group approximation; criticality calculations; cross-section processing; buildup and depletion calculations; and modern reactor analysis methods and codes.

Nuclear Radiation Shielding – The basic principles of radiation interactions and transport, especially as related to the design of radiation shields are studied in this course.

Nuclear Fuel Cycles and Safeguards Systems – This course educates students on the design and implementation of nuclear material safeguards systems for nuclear fuel cycle systems. A description of the civilian and military nuclear fuel cycles is given including the physics of the fundamental components of the fuel cycle (including enrichment, fuel fabrication, reactors, and reprocessing); enrichment and conversion; reactor fuel design and fabrication; in-core fuel management; and reprocessing and recycling. The course also details the fundamentals of nuclear material safeguards including material protection, control, and accounting practices; the IAEA system of safeguards; the additional protocol; strengthened and integrated safeguards; application of NDA and DA to safeguards; and application of measurement techniques to reactors, fuel fabrication facilities, reprocessing plants, enrichment plants, and critical assemblies.

Radiation Detection and Nuclear Material Measurements – This course educates students on methods and instruments used for quantitative measurements of nuclear and radiological materials. The focus is on neutron and gamma-ray radiation detection including the use of gas-filled detectors, scintillation detectors, and semi-conductor detectors. Topics also include measurement of uranium enrichment; measurement of plutonium isotopic compositions; neutron coincidence counting; active neutron interrogation; irradiated fuel measurements; and holdup measurements.

Critical Analysis of Nuclear Security Data – This course serves as a capstone for the MS-NNP degree program. The course requires students to synthesize content from all of their other courses to critically analyze a hypothetical nuclear security event. This is a project-based course which students study the analysis of nuclear security events and threats and actively assess them using hypothetical, yet realistic, data (including, but not limited to) overhead imagery; mass and gamma-ray spectroscopy from air, biota, soil, and water samples; press reports; watchdog group reports; historical details; seismic data; ultrasound data; nondestructive radiation measurements of materials; destructive analysis of materials; export control information; and safeguards accounting data.

2. Future Curriculum

As previously mentioned, TAMU has partnered with two other prestigious universities to develop a new academic program on nuclear security that will be shared among the three institutions. The below five courses could potentially constitute a comprehensive specialization in nuclear security for a nuclear engineering graduate student. It is envisioned that they may serve as a nuclear security specialization for a Master of Science degree program or as a graduate certificate in nuclear security. The descriptions of the courses are included below. It is envisioned that classes will begin to be taught in the fall of 2011 and hence, the first graduates are expected as early as the spring semester of 2013.[1]

Threat Assessment and Analysis – This course is to educate students on conducting threat assessments of non-state actors in the fields of nuclear and radiological security. It is envisioned that this course will examine the history of threats and security issues in an effort to better understand terrorist groupings, their motivations, and attack methodologies.

Detector and Source Technologies – The primary focus of this course is on the theory behind radiation detection systems, sensors, and source technologies for security-related applications.

Applications of Detectors/Sensors/Sources for Radiation Detection and Measurements – This laboratory-based course will provide a hands-on overview of photon, neutron and charged particle detection technologies in field deployable devices and portal monitors.

Global Nuclear Security Policies – This course will focus on the national security strategies in the areas of counterterrorism and nonproliferation specifically. Policies and roles of various U.S. agencies (the Department of Homeland Security, the Department of Energy/National Nuclear Security Administration, Nuclear Regulatory Commission, the Department of Defense and Environmental Protection Agency) and transnational groups will be discussed, especially with regard to motivation and potential capabilities ranging from Improvised Nuclear Devices to radiological dispersal devices.

Design and Analysis of Security Systems for Nuclear and Radiological Facilities – This course examines methods for planning and evaluating nuclear security activities at the State and facility level and will provide the tools necessary for characterizing the adversary, categorizing targets and determining the consequences associated with the failure to protect targets. Furthermore, detection and delay technologies, on-site and off-site response strategies, evaluation of insider threats, mathematical methods for evaluating risk due to the threat and the security system design and methods for risk minimization and system optimization will be studied.

IV. CURRENT TEACHING TECHNIQUES

In addition to the coursework and curriculum outlined in Section 3, NSSPI is utilizing novel teaching techniques to benefit students in the MS-NNP program. This section will discuss the various methods explored and currently implemented for developing next-generation safeguards experts.

1. Graduate-Level Research

Paramount to effective education for graduate students is a rigorous research program in nuclear nonproliferation, safeguards, and security. Since 2004, NSSPI students have been paired with or sponsored by project leads at various U.S. national laboratories to work in a myriad of areas including nondestructive assay, containment and surveillance technologies, proliferation resistance analysis, physical security science, border security technologies, latency analysis, attribution analysis and forensics, and others. The students work in small groups that often include other students from disciplines outside of nuclear engineering including international affairs student as well as full-time members of the NSSPI research staff. Commonly, the projects include conducting research using the unique facilities at the sponsoring national laboratories (Fig. 1).

Figure 1. TAMU students (Dan Strohmeyer and Alissa Stafford) take spent fuel measurements at ORNL with TAMU professor (William Charlton) and ORNL and LANL staff (Steven Saavedra and Andrew Hoover)

2. Practical Experience

In addition to conducting hands-on research for their MS thesis work, NSSPI students are afforded other opportunities that foster a culture of comprehensive education that goes beyond mere theoretical education. Via the three specific activities described in the following subsections, students within the program gain an unprecedented amount of practical knowledge and experience otherwise not available to them within the classroom.

A. Hands-On Laboratory Experience

Every semester, NSSPI, with staff at the Oak Ridge National Laboratory (ORNL), provides the opportunity for graduate students within the MS-NNP program to complete a week-long practical course at ORNL's Safeguards Laboratory (SL). The course alternates between hosting undergraduate and graduate nuclear engineering students each semester. This activity helps the students understand and appreciate basic material control and accounting technologies focused specifically on detecting and measuring special nuclear material using NDA techniques. The week-long class was first developed by TAMU and ORNL SL staff in the Spring 2007 semester. It borrowed heavily from the vast experience ORNL SL staff had obtained in providing training courses on NDA techniques to professionals from various international institutions. Working closely with the ORNL staff, NSSPI coordinated this course to focus around topics the MS students learn as part of the aforementioned Detection and Measurement of Special Nuclear Material course from Section III.1.

The time spent at the SL for students complements the theoretical education of the students. Understandably, other universities have followed the example set forth by TAMU in this venue, and the ORNL staff has expressed the great successes of collaborating with universities within their region and beyond. This has been a fruitful collaboration for ORNL, TAMU, NSSPI, and the MS-NNP students.

Further, in recent courses, students from the TAMU Bush School of Government and Public Service studying nonproliferation and international security and other foreign relations areas have also been hosted in the SL course at ORNL (Fig. 2). This has provided policy students the opportunities to better understand the limitations and applications of various technologies as applied to safeguards and nuclear security and fosters enhanced communication between the future technical and policy experts. This integration of policy and technical students has been very fruitful for the students attending this course.

Figure 2. TAMU Students (MS-NNP and Bush School students) at ORNL

B. Foreign Field Experience

As part of the capstone course discussed in Section III.1, MS-NNP students at TAMU are afforded the opportunity to travel to nuclear fuel facilities in other countries to discuss safeguards applications and effects on operations. This endeavor is commonly referred to as the Foreign Field Experience (FFE) and has been conducted jointly with two Russian universities with established nonproliferation and international security education programs: the Moscow Engineering and Physics Institute (MEPhI) and the Obninsk State Technical University's Institute for Nuclear Power Engineering (IATE). As of 2007, students from the three academic institutions (Fig. 3) have visited, toured, and openly discussed safeguards applications at nuclear fuel cycle facilities in France, the United Kingdom, and Switzerland. Hosting organizations have welcomed the students into their facilities and have shown candor when discussing their operations and international safeguards applications (much to the delight of the students).

The FFE is a unique opportunity for students from the U.S. to witness full-scale fuel facilities (ranging from reprocessing plants, fuel fabrication plants, and enrichment plants) and to discuss topics they have received conceptual instruction on for the previous two years while in the MS-NNP program at TAMU. Furthermore, students from the Russian institutes, MEPhI and IATE, receive the opportunity to visit western-style facilities and gain an appreciation of applied safeguards features that benefit their future careers. Students on both sides gain the opportunity to expand their own professional networks of nuclear experts and, it is hoped, that when the students' paths cross in the future, the warmth instilled by the FFE carries through and future professionals can rely on these relationships for the benefit of the cause.

Figure 3. Students and professors from TAMU, MEPhI, and IATE at the Nuclear Decommissioning Authority

C. Summer Internships and Summer Safeguards Courses

As implied in Section IV.1, students in the MS-NNP program are encouraged to participate in summer internships at the national laboratories where they can continue their research under the direct guidance of their national laboratory sponsors/mentors and other subject matter experts. Students gain additional knowledge outside of the expertise at TAMU and make contacts with possible future employers. The national labs gain a cost-effective research resource, establish enduring contacts with academia, and acquire an opportunity to evaluate potential future employees.

The TAMU MS-NNP students have been prominent participants in the summer safeguards courses at the national laboratories sponsored by the Next Generation Safeguards Initiative (NGSI).[3] These courses provide an educational opportunity to the students that would be difficult to acquire at a university. They have an opportunity to hear lectures from leading experts at the national laboratories and to participate in laboratory practical exercises using the advanced materials and technologies available throughout the DOE complex (not available at TAMU).

D. Nuclear Safeguards Education Portal

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 NGSI program, funded a large number of students to participate in internships across the laboratory complex over the past several summers. 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. Initial summer efforts were hampered by this fact. Students with technical backgrounds (such as nuclear engineering) were subjected to fundamental topics that were necessary for non-technical students during the introductory sessions. This led to the technical students being under-stimulated and under-challenged through the beginning of the course. Due to this, NGSI provided funding to NSSPI to develop NSEP. In 2009, the first 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 initial modules were:

- 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 served to provide educational resources for students with an interest in nuclear safeguards and the security of nuclear materials anywhere in the world. All current modules are globally available regardless of enrollment at TAMU. All of the initial modules are intended to be completed in a few hours. They consist of reading materials, supporting video lectures from professors at TAMU and subject matter experts from the national labs and industry (where appropriate), along with links to additional resources. The online, asynchronous nature of the modules provides students with the opportunity to complete the module at their own pace.

Since June 2009, NSEP has been accessed by approximately 1100 unique users. "Basic Radiation Detection" is the module accessed most frequently, specifically the section concerning Semiconductor Detectors.[4] The complete breakdown as of July 2011 is as follows:

Table 2. Module and Number of Users for NSEP

Module	Number of users
Basic Nuclear and Atomic Physics	280
The Nuclear Fuel Cycle	300
Basic Radiation Detection	500

For comparison, a typical graduate level course covering any of these topics may have 10-20 students. Asynchronous distance education provides the opportunity to reach a considerably larger audience. While many of these users are concentrated around the U.S. national laboratories and DOE HQ, other University programs have included these modules as required assignments and a significant body of international users has been observed.

As of late fall 2011, NSEP consists of seven independent modules and two reference units for educating next-generation safeguards and nonproliferation experts around the world. The additional modules are:

- Statistics as Applied to Nuclear Safeguards
- Nuclear Material Accountancy
- Physical Protection
- Containment and Surveillance

The two additional reference units are a detailed history of the Manhattan Project (from a technical aspect) and international nuclear material safeguards terminology (based on the IAEA glossary of terms). Furthermore, incorporated into each module are evaluation portions that allow students to assess their understanding of the subject matter in a private manner. The results are emailed directly to the course taker and serve the purpose of applying knowledge he/she acquires from NSEP. It is envisioned that this can prove useful for institutes that would like to use the modules as prerequisites for their own programs.

Overall, it is believed that these modules will provide a more profound understanding of the various aspects of the subject matter and will be available beyond the student population at TAMU.

V. EDUCATION USING A VIRTUAL ENVIRONMENT

NSSPI has developed courses deployed via distance technologies that benefit the students in the MS-NNP program at TAMU via distance education. Unique among universities, TAMU has developed and maintains a virtual campus within Second Life (a 3D, virtual online realm that is open access to all TAMU students, regardless of major or level of study). Within this space, NSSPI has created a classroom and has effectively taught courses in the project to facilitate teaching where the students and professor are separated geographically. Every user interacts via a user-created avatar that literally sits in a classroom and can participate in a lecture. Furthermore, when discussing more complex topics, the avatar is able to tour the interior workings of a reactor or physically witness the interaction of a photon when striking any given medium. Voice chat and multimedia features are available to facilitate participation in individual and group activities limited only by the imagination of the world's creator.

Some courses discussed in Section III.1 have held classes taught in Second Life and student response was positive. As is seen in the collection of pictures in Figure 4, a white board is used to convey equations, slides are presented, lectures are provided verbally via voice chat, and students witness the interior features of an operating reactor. In the future, it is foreseeable that Second Life can be used to educate students in physical security sciences by exploiting the capabilities of the 3D realm and combining them with game play to create red team/blue team exercises among other subjects which could benefit from Second Life.

Figure 4. Screen captures from NUEN 656 in Second Life

VI. FUTURE ACTIVITIES

There is a growing need for trained individuals in nuclear safeguards and security. Lately, if students had not participated in the TAMU MS-NNP program, all training would begin once a student joins the workforce after graduation. Though with the current activities outlined in this paper, TAMU is alleviating the burden of on-the-job training in these areas but more can be done.

1. Progressing Nuclear Security Education

As discussed in Section III.2, TAMU, with two other academic institutions, is currently building a foundation to develop nuclear security curriculum. Other classes that focus on specific topics in nuclear security could be developed. These classes could include, but not be limited to:

- Consequence Management – It is envisioned that this class would discuss the response efforts behind a catastrophical, radiological incident.
- Counter-Terrorism – Building on the aforementioned course on threat assessment and analysis, this class would focus on counter terrorism tactics and analyses.
- Nuclear Forensics – This course would focus on the science of determining the physical, chemical, elemental and isotopic characteristics of nuclear (or radiological) material of unknown origin. It is foreseen that this course would include a radiochemistry laboratory component.

Within the realm of developing nuclear security educational capabilities, small course modules of 1 to 2 weeks in length could be designed to complement current courses taught in both the graduate and undergraduate nuclear engineering curriculum. These modules would provide brief overviews of areas of interest in nuclear security and would include:

- Civilian/ Military Fuel Cycles
- Fuel Chemistry
- Separation Chemistry – Actinide/Lanthanide Properties Waste Management
- Forensic Science Fundamentals
- Introduction to Nuclear Forensics and Attribution
- Physical Protection Systems and Technologies
- Radiation Safety and Protection
- Risk Assessment and Nuclear Security Measures
- Vulnerability Assessment of Physical Security Systems for Nuclear Installations
- Nuclear Materials in Transportation (Transportation Security)
- Security Fundamentals
- Protection Against Sabotage

2. Additional NSEP Modules

NSSPI has begun determining in which ways the current offerings in NSEP can be expanded to encompass more subject matters pertinent to nuclear nonproliferation, safeguards, and security. Subjects of interest under consideration for future development have been discussed with various potential sponsors and future possible customers in various areas, agencies, and organizations:

- Nuclear Security
- Introduction of Nuclear Forensics
- Proliferation Resistance in the Nuclear Fuel Cycle
- Radiation Safety and Protection
- Nuclear Terrorism

3. FFE Beyond Western Europe

In recent years of the MS-NNP at TAMU, NSSPI has worked diligently in assuring TAMU students participate in the previously-discussed FFE with Russian students. Facilities in the UK, Switzerland, and France have proven beneficial in many regards but, in light of recent advancements in nuclear transparency and cooperation with other nations, the idea of conducting FFEs in other countries for students from TAMU and the host countries is being actively considered by sponsoring organizations. No formal decisions have been made but NSSPI will proceed by discussing these ideas with academic institutions in potential host countries. The four main requirements for hosting an FFE is (1) a robust nuclear fuel cycle is present in the country, (2) nuclear facility operators are willing to discuss applied safeguards measures with students for educational purposes only, (3) the facilities can host outside visitors at no cost, and (4) a similarly-positioned academic institution that can match involvement of its students and staff in joining the TAMU contingency in visiting the facilities. Countries of interest for student visits and discussions include Japan, the Republic of Korea, and India.

4. Joint Short Courses

NSSPI staff and students have collaborated in the past to jointly develop short courses with academic institutions in other countries that have shown a keen interest in educating their students in nuclear nonproliferation, safeguards, and security. Potentially, the next short course on nuclear safeguards and nonproliferation is being discussed to occur at the Tomsk Polytechnic University (TPU) in Tomsk, Russia in summer of 2012. It is envisioned that staff, faculty, and students from TAMU and TPU will co-develop lectures and exercises for an international short course to be held at the TPU campus for American students and English-speaking Russian students. It is also possible to include interested students from other academic institutions elsewhere in Russia or from other nations.[5]

VII. CONCLUSIONS

The TAMU Nonproliferation Specialization and various educational techniques being utilized by NSSPI staff and TAMU faculty were discussed in this paper. The general philosophy of the MS-NNP program is based on the concept that nuclear nonproliferation is an engineering problem, within a policy framework, that it includes a multi-disciplinary component and is highly dependent on practical experience and infusing state-of-the-art educational techniques. The highlighted success of this program speaks to the commitment of TAMU and NSSPI as well as the growing interest of the subject matter in college-level students wanting to make a substantial difference in society using their unique skills. With recent developments across the globe in matters of nuclear security and safeguards, students are seeing the potential of these areas to grow into meaningful career opportunities. TAMU's program will continue to develop in the future with continual feedback from the primary customers: the national laboratories, government agencies, and the IAEA. Embracing state-of-the-art educational technologies is paramount to maintaining a successful educational program in the ever-evolving area of nuclear nonproliferation and safeguards.

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