Proceedings of the INMM & ESARDA Joint Virtual Annual Meeting
August 23-26 & August 30-September 1, 2021

Delivering Graduate Nuclear Security Education: Teaching Nuclear Security Policies to Nuclear Engineers

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ABSTRACT

Pennsylvania State University's nuclear engineering program offers a master's degree in Nuclear Security. This program is the first master's degree program offered in the USA and includes five technical and policy-oriented courses along with other nuclear engineering courses. One of the policy courses, namely Global Nuclear Security Policy, includes national and international nuclear security policy topics. This course is taught from both a technical and a policy perspective, with joint instruction from two professors whose expertise includes both areas. The primary goal of this course is to introduce students to the policies and laws that are intended to provide a secure environment for the pursuit of legitimate nuclear activities. The topics discussed in this course include: Perspectives on International Relations – Context for Nuclear Security Policy; State Motivations for Nuclear Weapon Proliferation; US Domestic Nuclear Strategy "after" the Cold War; National Nuclear Security Decision Making; Nuclear Security Structure and Strategy; Overview of Civilian Uses of Nuclear Technology & Advanced Nuclear Reactor Technology; The IAEA and the NPT; The Future of Multilateral Treaties in the Current International Climate: The CTBT, the FMCT, and others; Domestic and International Export Controls for Nuclear-Relevant Technologies; Radiation Dispersal Devices and Non-State Actors; Counter-Proliferation and US Nuclear Security Strategy; Demilitarization and Disarmament. After completion of the course, students should understand technical and policy implications of:

- The origins and history of controlling nuclear materials
- The International Atomic Energy Agency and other international organizations relevant to nuclear safeguards and security
- Increased civilian use of nuclear technology
- The role of present and future technologies in the development of policies
- How US and international strategies, policies, and laws interact to promote global nuclear security
- The strains imposed on the existing framework by the increased risk from non-state actors and possible approaches to better controlling those risks
- Approaches to the reduction of nuclear material and radioisotope inventories

This paper will provide an overview of the course as it aims to ensure that nuclear engineers with a heavy technical background are able to learn to navigate the policy sphere, and potentially move into a more blended career area if they wish.

Introduction/Course Philosophy

The aim of the course is to acclimate master's candidate nuclear engineering students of all ages and levels of expertise to the world of myriad issues that nuclear security and

nonproliferation policy encompass. In this endeavor, the lectures and course work cover both technical aspects of nuclear security and nonproliferation, as well as policy aspects. Additionally, the course seeks to enrich students beyond the standard fare of nonproliferation and arms control, to widen the discussion to broader issues pertaining to nuclear weapons, nuclear energy, sustainability, environmental issues, history, and relevant policy paths forward.

The Course Format

Originally, the course was provided as a regular in-person course, with the option for passive virtual participation by World Campus/distance students. These students were those not located physically at the State College, PA campus, for various reasons. Many WC students have full time employment and are attending virtually in order to continue with their careers from all over the USA, and all over the world. This format was effective, but had a disadvantage for World Campus students. In this model, the in-person students would meet weekly for three hours, during which time they would hear lectures, and hold relevant discussions, as well as participate in small exercises. The entire three-hour weekly session would be recorded, and then posted for the WC students to watch asynchronously. The WC students could then post comments and questions in the PSU Blackboard, which would be answered by both the professor, and by other in-person and WC students who wished to engage (engagement is both encouraged and required for final grading purposes).

While the above model was effective for students, COVID caused a reformatting of the course, since no one was able to participate in-person. During COVID, the class became fully remote for all, even for those students who continue to reside at State College. The new format included a lecture on the week's topic, recorded and uploaded to be watched asynchronously, at the start of the week. Additionally, readings would be assigned in advance of the lecture, with a quiz on the lecture due in short order for participation credit. Then, on Friday of the given week, a synchronous Zoom discussion session would be held, with very active participation by all students expected and required. The new model had many advantages for all, particularly due to the increased involvement of the remote students, who no longer were passively observing the lecture and the ensuing discussion, but who were able to participate and to bring their expertise and insights to the class, thus enriching their fellow students all the more.

Grading

Unlike traditional nuclear engineering courses, this course focuses mainly on the development of an intellectual product that can serve students differently as they enter or continue their careers. While there are weekly quizzes and participation requirements, the main graded items are a serious term paper, and a mid-term exam. The mid-term exam is nothing revolutionary, but seeks to confirm that rather than rote memorization, students are able to explain the complicated nuances of policy, and the areas where technology and policy intersect inseparably. The most important deliverable of the semester is a term paper that should be of peer-reviewed, publishable quality, which deals with a pre-approved issue of relevance to the course, that is of professional interest to the student. The goal is that whatever topic is approved for the student to research and address through this assignment, the student will, upon completion of the project, be able to be considered a credible budding expert. Additionally, the instructors encourage students to pick a relevant and timely topic that is of interest for them in the next steps of their careers. Past topics have varied widely but have included the following titles: Turnkey states and proliferation issues, pathways to denuclearization of the Korean Peninsula, the motivations of various states for either proliferation, or disarmament, IAEA safeguards-relevant topics, international treaties and regimes topics, non-state actors topics, various historical case studies (with critical analysis), technological/policy nexus questions, and

many other relevant topics. The students not only produce a full length, fully cited term paper, they also make a formal presentation to both their instructors and peers, via recorded Zoom, which weighs in to their final paper grade.

Traditional and Non-traditional Themes

While the course themes center around traditional nonproliferation, nuclear security, and nuclear engineering topics, there are additional thematic elements of the course. The instructors want to emphasize the dual-use nature of nuclear technology, and to hammer home how it can be both a destructive, and also a truly hope-inspiring, technology. In order to look at this, the instructors introduce students to topics regarding energy justice, climate justice, and nuclear testing and weapons legacies. These elements have not traditionally been present in many nonproliferation policy courses, and can allow students to engage with the content in a more nuanced way. Additionally, a deep dive into history is a key part of the course. The instructors seek to emphasize how the legacy of the Cold War continues to be at play, even with many generations separating the original source of enmity between the two first nuclear powers. In tandem with this theme, the course grapples with open-ended questions about both the ethics of nuclear weapons, and the ethics of nuclear disarmament. Another topic that the instructors include is the overlapping roles that global power politics, nuclear weapons, and past and current colonialism play. Finally, we include discussions of diverse perspectives (gendered perspectives, environmental and social justice perspectives, and practical disarmament challenge perspectives).

The Makeup of the Participants

The students who participate in the course are, of course, self-selecting. The vast majority are nuclear engineering graduate students. Approximately 40% tend to be in-person students at the State College campus, and the other 60%, World Campus students. One of the wonderful things about the course is that this mixture allows for an excellent level of cognitive diversity, across age, demographic, and professional knowledge and expertise. Additionally, it allows for participation from diverse geographic regions around the world. In terms of enrollment, the course typically has between 30-40 participants.

The Benefit of the Blended Model

This course is blended on many levels. First of all, the expertise of the instructors is blended; with one focusing in their career mainly on technical nuclear engineering topics, and the other, primarily focusing on policy-oriented topics and efforts professionally. That said, both instructors have expertise on both sides of the aisle. Secondly, the student audience has differing backgrounds, which contributes to an excellent level of cognitive diversity, and many are non-traditional students, who have the benefit of professional experience already. While many, almost all, are part of the graduate nuclear engineering program at Pennsylvania State University, many are currently practitioners in their careers in various fields of engineering or even policy-relevant spaces, which means that the wide-ranging knowledge and interest of the participants adds to the richness of the course discussions and paper topics. Finally, the fact that the topical course material is not strictly policy, or strictly technical, means that students get a very good feel for how important it is to study policy and technology together, and how both engineering/technical decisions, and policy decisions, need to be considered in light of their counterpart concerns. The many benefits described here continue to show themselves, as several of the students who participated in this course have since entered one of the related fields, and are contributing to it in meaningful and lasting ways.

KENAN ÜNLÜ

Dr. Kenan Ünlü received his PhD degree in Nuclear Engineering from the University of Michigan. He was a faculty member and the Manager of Neutron Beam Projects at the University of Texas at Austin (1990-1998). He joined Cornell University faculty in 1998 as the Director of the Ward Center for Nuclear Sciences. Since 2002 he is a faculty member at the Pennsylvania State University. He is the Director of the Radiation Science and Engineering Center, Professor of Nuclear Engineering and Affiliate Professor at the School of International Affairs. Dr. Ünlü has over thirty years of research reactor administration experiences for research, education and service activities in leadership role. His experiences include development and applications of nuclear methods for advancement of nuclear science and engineering, utilizations of research reactors for scientific research, and nuclear security education and research. He initiated and build a nuclear security education program at Penn State.

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Katherine Bachner is currently the United States Support Program (USSP) Coordinator to IAEA Safeguards at the U.S. Mission to International Organizations in Vienna (UNVIE), Austria, as well as the International Safeguards Project Office (ISPO) Liaison Officer for Brookhaven National Laboratory (BNL). Prior to her current role, she was the Group Leader for Nonproliferation Policy and Implementation at BNL. She has also worked at the U.S. Department of Energy/National Nuclear Security Administration, and at the United Nations Office for Disarmament Affairs. She has worked in nuclear nonproliferation for the past 12 years, and has graduate degrees in nuclear engineering, international policy, cultural anthropology, and international nuclear law.