# Building a Foundation for the Future of Nuclear Security

*By Erika Suzuki, Bethany L. Goldblum and Jasmina L. Vujic*

> *"The need for understanding of today's evolving nuclear threats is critical to informing policy decisions and diplomacy that can move the world toward greater nuclear security. The scientific underpinnings for such an understanding are remarkably broad, ranging from nuclear physics and engineering to chemistry, metallurgy and materials science, risk assessment, large-scale computational techniques, modeling and simulation, and detector development, among others. These physical science disciplines must be combined with social science fields such as public policy, political science, international relations, international law, energy policies, economics, history, and regional studies in order to yield a deep understanding of today's nuclear security challenges."*
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> -James Doyle, "Nuclear Security as a Multidisciplinary Field of Study," Los Alamos National Laboratory, 2008

The future of domestic and global nuclear security depends on today's university students and young professionals feeding the pipeline to supply the requisite scientific workforce. To develop the next generation of nuclear security experts, universities must not only train students in technical nuclear science but also provide a comprehensive educational platform including nuclear energy and weapons policy in the context of the current political science architecture. Nuclear-related education programs are gaining traction, bolstered by the 2010 Nuclear Forensics and Attribution Act and other government initiatives such as the National Nuclear Security Administration (NNSA)'s Global Threat Reduction Initiative (GTRI).[1] However, many of these programs are geared towards training students already engaged in nuclear science graduate programs. To maintain a steady stream of experts in nuclear security, universities must also actively recruit students in the early stages of their academic career by incorporating undergraduate educational initiatives and pre-professional development through both traditional classroom-based and extracurricular programming.

A working group model established at the University of California, Berkeley provides a pathway through which educational institutions with an established nuclear science program can initiate and

[1] National Nuclear Security Administration. (2013) GTRI: Reducing Nuclear Threats [Press release]. Retrieved from http://www.nnsa.energy.gov/mediaroom/pressreleases/nuclearsecurityprgm052813

further enhance nuclear security educational programming targeting students from all academic career stages.

## The PRI(M)$^3$E Model

The PRI(M)$^3$E model was developed by the UC Berkeley Nuclear Policy Working Group (NPWG) in October 2012.[2] The model is derived from the three-fold mission statement of the NPWG. The first focus is to educate undergraduate students on important issues in nuclear security by providing supplementary education on nuclear technology and policy. The second aim is to foster collaboration between students and professionals from technical and social science fields. The third core goal of the NPWG is to generate original policy recommendations and technical working papers to contribute to the nuclear security field. From these primary objectives, the NPWG developed a foundational model to educate the next generation of nuclear scientists and policymakers.

The PRI(M)$^3$E model features seven key components that are essential for developing and sustaining an enduring nuclear security workforce:

- **P**ioneering
  - Group discussions, collaborative research, and open communities facilitate the innovation of novel techniques for strengthening nuclear security through technological advancements and action-oriented policy. This environment allows for the unconstrained development of best practices for the education of undergraduate and graduate students in nuclear security.
- **R**esearch
  - A research-based working group allows members to collaborate on technical and policy-focused research projects addressing an array of critical nuclear security topics.
- **I**nterdisciplinary
  - Interactive workshops draw from both the physical and social sciences, encouraging students to develop a strong foundational knowledge base in nuclear security to best inform research projects and policy recommendations.
- **M**$^3$
  - **M**entorship
    - Opportunities are made available for undergraduate and graduate students to work closely with senior mentors to share insight, career advice, and guidance on next steps towards a career in the nuclear security field.
  - **M**ulti-level

[2] Goldblum, Bethany. "UC Berkeley Nuclear Policy Working Group." 2013 Web. 19 Jul 2013.

        - Students at all stages of their academic career- from freshmen through senior-level undergraduate and graduate students, post-doctoral researchers, staff scientists from the university and the national laboratories, and non-academic professionals engage in collaborative needs- driven research in nuclear security and associated applications.
    - **M**ultimedia
        - Participants use a variety of media including various audio-visual presentation platforms, workshops, expert panel discussions, student seminars, and digital electronic technology to convey important concepts and foster debate.
- **E**ducation
    - Education of working group members, the campus community, and the general public via accurate, timely information on current developments in nuclear security technology and policy is central to the multistage mission.

Implementation of the PRI(M)$^3$E model serves as a framework that enables the NPWG to fuel the nation's nuclear security workforce pipeline. Each component of the PRI(M)$^3$E model uniquely targets the recognized need for interdisciplinary training of nuclear experts, integrates a research unit into the overall educational platform, and translates multi-level interaction into mentorship to provide undergraduate and graduate students with career guidance in both the scientific and policy fields. The working group is designed to generate a cadre of experts with both well-rounded and in-depth knowledge of the technical and policy-oriented aspects of nuclear security through comprehensive, research-based, educational programming.

The NPWG is a low-cost, high-impact model. The budget for running a successful working group is minimal compared to the potentially substantial financial and institutional investment required to establish a certificate or degree program, while the organizational structure of the PRI(M)$^3$E model allows for the achievement of comparable educational objectives. Should institutional priorities shift to the adoption of more traditional educational models, the PRI(M)$^3$E model lays the foundation for the future development of degree programs. Further, the inclusive nature of the working group makes it accessible to students at all levels as well as to the general public. Student retention represents the primary challenge to the success of the PRI(M)$^3$E model. The informal nature of the working group can result in difficulties maintaining a core group of students, many of whom may juggle numerous responsibilities and commitments, including academics, work, and other extracurricular activities. To reduce attrition, the NPWG strives to actively engage members using a variety of media and activities, and works with members to develop flexible working practices.

## Beyond the Foundational Model: Practices and Results

The PRI(M)$^3$E model is particularly instrumental at UC Berkeley, which has a highly divided campus layout like many research-oriented universities. Almost all of the social science departments are located on the southwest side of campus, while the physical sciences are based on the northeast side of campus. As a result, students from different disciplines often do not physically interact with one another, and opportunities for interdepartmental collaboration between the technical and social sciences at the undergraduate level are sparse. The NPWG serves as a bridge between these two spheres on campus, and establishes a space in which students from various disciplines can interact and collaborate on interdisciplinary research projects.

The principal goals of the PRI(M)$^3$E model are institutionalized through the activities of the NPWG. At weekly research meetings, members discuss research progress and future direction, and contribute to colloquia where participants present on a nuclear security topic of their choice. The multidisciplinary nature of the NPWG is one of its greatest strengths, as students from the nuclear engineering, physics, astrophysics, electrical engineering and computer science, political science, and public policy departments share knowledge and draw on their individual strengths to contribute to joint research projects and weekly seminar presentations. This working group series provides students with opportunities to continually develop dynamic working relationships with other students, as well as senior mentors. The development of close, effective mentor relationships is highly beneficial to undergraduate professional development, as advisors encourage students to apply for internships at the national laboratories or other nuclear security institutions, impart career and internship advice, and support the academic growth of students throughout the learning process.

To expand its educational outreach initiative to the general public, the NPWG hosted its first annual Nuclear Security Panel in April 2013, which featured prominent nuclear security experts well versed in both the technical and social science aspects of the field (see Fig. 1). The panel event generated lively debate and educated the broader campus community on current issues in nuclear forensics. This interdisciplinary team of experts provided the UC Berkeley campus and the public with a multifaceted examination of the role of nuclear forensics in combating nuclear terrorism, and also served as a public forum for discussion.

Figure 1: Nuclear Security Panel featuring (from left to right) Ian Hutcheon, Michael Nacht, Jasmina Vujic (moderator), Raymond Jeanloz, Stan Prussin and Jay Davis.

The NPWG also showcased its practices and results at several technical and policy conferences to disseminate the PRI(M)$^3$E methodology for student engagement and communicate contributions to the nuclear security field in the form of original policy recommendations (see Fig. 2). These events provided undergraduate and graduate students with professional development opportunities, occasions to cultivate and hone presentation skills, and networking opportunities with nuclear security professionals from around the globe. Feedback from these colleagues has been vital to the enhancement of working group practices and research project design.

Through these PRI(M)$^3$E-based endeavors, the NPWG has trained a first-year cohort of fifteen members and conducted educational outreach on numerous occasions in both technical and public policy capacities.

Figure 2: Institute on Global Conflict and Cooperation 2013 Winter Public Policy and Nuclear Threats Conference. NPWG Undergraduate Research Assistant Erika Suzuki with Ambassador Linton Brooks.

Institutional support has been critical to the success of the NPWG and is essential for the long-term efficacy of the working group model. The NPWG is currently supported through an educational programming grant provided by the Nuclear Science and Security Consortium (NSSC) through the Institute on Global Conflict and Cooperation. The NSSC is a $25 million grant with UC Berkeley as the lead institution that was awarded by the National Nuclear Security Administration (NNSA) to support its NA-22 Nonproliferation Research and Development mission. The purpose of the NSSC is to train and educate experts in the nuclear security field using "an end-to-end approach, from recruitment of undergraduates to early career phases," – the SUCCESS PIPELINE (*Seven Universities Coordinating Coursework and Experience from Student to Scientist in a Partnership for Identifying and Preparing Educated Laboratory-Integrated Nuclear Experts*). The NPWG operates at the foundational level, recruiting and educating undergraduate students, providing them with opportunities to collaborate with and learn from advanced students and professionals actively engaged in the nuclear security field.

**SUCCESS PIPELINE NSSC[3]**

At the input end of the pipeline, highly promising undergraduate and graduate students who have shown relevant interests are exposed to nuclear security. The program couples basic science research to technological developments relevant to the nuclear security mission. Student education includes hands-on training in a broad set of experimental disciplines—at university facilities and, as a formally constructed and supported aspect of their education, at the Lawrence Berkeley, Lawrence Livermore, Los Alamos, or Sandia National Laboratories. Between the academic and the national laboratory partners exist an array of facilities including nuclear reactors, cyclotrons and other particle accelerators, as well as detector development and characterization facilities. Summer schools and seminars broaden student exposure to a wide range of topics in the nuclear security mission. This approach is designed to not only recruit but also retain top students by exposing them to a diverse and exciting research portfolio of critical importance to the U.S. nuclear security mission. The graduate will be a well-rounded professional ready to contribute to nuclear security and step into leadership roles in the field.

## Future Vision

In an effort to further develop and sustain an enduring expertise pipeline, the NPWG will be launching its Nuclear Security Initiative (NSI) in the coming year. The purpose of the NSI is to extend the NPWG across NSSC partner institutions to engage a larger cross section of students in interdisciplinary nuclear security science, provide foundational knowledge on nuclear science and policy, and train

[3]Vujic, Jasmina. "National Science and Security Consortium: SUCCESS PIPELINE." 2013 Web. 19 Jul 2013.

students to work collaboratively on technical research projects and policy recommendations. The NSI is a refined version of the NPWG's efforts based on the PRI(M)$^3$E model, and expands on the NPWG's research focus on nuclear forensics to include nuclear terrorism, nuclear material security and nonproliferation. The NPWG thus serves as a feeder for the NSSC's SUCCESS PIPELINE at a micro-level, and duplication of its practices via the NSI will support the development of a robust national nuclear security network among universities, national laboratories, government agencies, and industrial institutions.

## Conclusion

Universities are increasingly impacted by state and federal budget cuts, so the role of institutional support has intensified. Most prominently, the recent sequester cuts will reduce the available pool of research funds by an estimated $1 billion.[4] This will not only affect the ability of researchers at universities and national laboratories to obtain grants from federal science-based organizations, but will also potentially decrease the number of graduate students admitted to science and engineering programs at universities that rely heavily on federal funding.[5] The loss in funding coupled with a reduced number of doctoral students in these fields may hinder scientific progress and shrink the pipeline as fewer students pursue advanced degrees in science and engineering. Cultivating the future scientific workforce is crucial to operations at the national laboratories, which will face a shortage of staff scientists in the coming years due to a combination of scheduled retirements and voluntary early retirement policies stemming from the sequestration budget cuts.

As we enter the new academic and fiscal year this fall, universities and other educational institutions will need to supplement losses in research and graduate programs with lower-cost, extracurricular modes of learning. The PRI(M)3E model is one such pathway to establish a rich environment for the generation of debate and novel direction on critical nuclear security issues while engaging students outside of a traditional classroom setting. This interdisciplinary approach to academic programming is crucial for securing the future of domestic and global nuclear security, as it provides a means for involving students from various disciplines to cooperatively address the multifaceted and vital nuclear issues that permeate the current landscape of national defense. Training future nuclear scientists and policymakers to collaborate on nuclear issues will forge better-informed and better-implemented nuclear policy and practices, and will ultimately result in the maintenance of a strong, sustainable nuclear security infrastructure.

[4] Anderson, Nick. "Sequester Cuts University Research Funds." *Washington Post*. N.p., 16 Mar. 2013. Web.
[5] Ibid.

***Erika Suzuki*** *leads the University of California, Berkeley's Nuclear Policy Working Group in support of the Nuclear Science and Security Consortium. Erika has taught three student elective courses on human rights, the politics of genocide, and California/UC labor policy that she developed through the Democratic Education at Cal program. She has also interned for Democratic Leader and Congresswoman Nancy Pelosi, the American Federation of State, County, and Municipal Employees Local 3299, and Berkeley Rent Board Commissioner Igor Tregub. She is an alumna of the 2012 Berkeley Haas School of Business Summer Program: Business for Arts, Science, and Engineering, and is a member of Delta Phi Epsilon, a co-ed, professional Foreign Service and international affairs fraternity. After graduating from UC Berkeley with a Bachelor of Arts degree in Political Science and Public Policy, Erika aspires to work as a nuclear policy analyst focusing on nuclear counterterrorism and nonproliferation efforts, and obtain an advanced degree in international security studies.*

***Bethany L. Goldblum*** *received a Ph.D. in Nuclear Engineering from the University of California, Berkeley in 2007. She served as a Clare Boothe Luce Chancellor's Postdoctoral Fellow at Berkeley before joining the nuclear engineering faculty at the University of Tennessee, Knoxville in August 2010. In January 2012, she returned to Berkeley as a member of the research faculty. Her research interests are in the areas of fundamental nuclear physics for nuclear security applications, nuclear-plasma interactions, technical nuclear forensics, and nuclear energy and weapons policy. From 2004-2006 she held the National Science Foundation Public Policy and Nuclear Threats Fellowship. She was a Project on Nuclear Issues Scholar at the Center for Strategic and International Studies and a member of the United States delegation to the China-India-United States Workshop on Science, Technology and Innovation Policy in Bangalore, India. She is the founder of the Nuclear Policy Working Group at UC Berkeley, an interdisciplinary team of undergraduate and graduate students focused on developing policy solutions to strengthen global nuclear security.*

***Jasmina L. Vujic*** *is Professor of Nuclear Engineering at the University of California, Berkeley. She received her Ph.D. in Nuclear Science from the University of Michigan, Ann Arbor, in 1989. After working at Argonne National Laboratory she joined UC Berkeley faculty in 1992. From 2005 to 2009 she was the Chair of the Department of Nuclear Engineering at UC Berkeley and in 2009/2010 she chaired the Nuclear Engineering Department Heads Organization (NEDHO). Her research interests are in the areas of nuclear reactor analysis and design, neutronics and neutron physics, non-proliferation and nuclear security, and engineering aspects of medical imaging and cancer therapy. She is currently a Principal Investigator for two large research projects (over $30 million): the Nuclear Science and Security Consortium and the Berkeley Nuclear Research Center, involving close to 150 students, faculty and*

*researchers from 7 partner universities and 4 national laboratories. Professor Vujic is the author of three books, the editor of 6 monographs and international conference proceedings, and the holder of one U.S. patent. She authored close to 300 research publications. Under her mentorship 24 students received the Ph.D. degrees and 22 received the M.S. degrees.*



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