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Application-based learning, a nuclear experimental laboratory in a field environment

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The role of trained nuclear engineers in emergency response operations has grown as new technologies have emerged both streamlining the radiological information collection process and complicating the professional analysis. Current technology provides the user with a simplistic experience that can very easily consist of just turning on the start button and letting the embedded scripts do the rest. However, the user must still provide the requisite experience and knowledge to further understanding the results of the data collected. The technology has been purposefully designed for many uses which often involve site characterization and recovery operations following a nuclear accident. In this type of accident, nuclear material may be strewn around a location and response personnel must characterize the site for situational awareness and protection of personnel. The nuclear engineering program at the United States Military Academy has developed an educational experience focusing in on three main aspects of nuclear engineering; nuclear power, nuclear weapons, and medical physics awareness. The cadets (students) at the Academy are immediately employed as commissioned officers in the United States Army following graduation.

Especially after the attacks of September 11, 2001, Army strategic leadership recognized that weapons of mass destruction were a major threat to National security and the accidents involving nuclear material were more likely a “matter of when” as opposed to a “matter of if.” Convinced that the Army and the Nation needed leaders that were technically prepared to combat such threats, the Department of Physics at the United States Military Academy petitioned the Academic Board to expand from a nuclear engineering sequence to a full-fledged academic major. This petition was accepted and West Point graduated the first nuclear engineering graduates in 2005.

Within the academic major, cadets are presented with three principle areas important to nuclear engineers; the operation of nuclear reactors, the design and effects of nuclear weapons, and the health effects and medical uses of radiation. In addition to experiencing field trips touring nuclear power plants and irradiation facilities, cadets are also required to participate in table-top exercises where they must articulate their knowledge in a multi-disciplinary forum focusing on nuclear engineering applications. The exercises provide cadets an opportunity delve into nuclear engineering applications and the surrounding military, social, political, economic, ethical, and environmental considerations.

The nuclear engineering (NE) faculty recognized that further application of radiation detectors in an operational environment was needed beyond the normal pristine laboratory experience where conditions are optimal for radiation detection and technology employment. The nuclear engineering program at West Point is able to take advantage of the training grounds located on the military reservation normally used for summer time military training. Subsequently, the necessary paperwork was filed with the Nuclear Regulatory Commission to allow licensed sealed sources to be used on a specific training site, commonly referred to as Camp Shea (Figure 1). During summer training operations, Camp Shea is used as a military operations in an urban terrain (MOUT) training range.

Figure 1. Pictures showing the entrance to the Camp Shea training complex located on the grounds of the United States Military Academy and cadets conducting radiation survey operations.

The West Point NE program is fortunate to possess numerous radiation detectors across the detection spectrum of ionization chambers, scintillation detectors, and Geiger-Mueller detectors. Likewise, radiation dosimetry is appropriately used to track radiation dose and account for radiation safety considerations. The program also possesses numerous radioactive sealed sources (Cs-137, Co-60, Eu-152, and Ba-133) that were used in the field laboratory experience.

Development of the laboratory, specifically designed for college seniors, was based upon the faculty’s years of experience working in US Army deployed environments and response training on Department of Energy national laboratories. Three primary goals were developed for the laboratory experience; 1) site characterization, 2) hands-on use of the equipment, and 3) analysis and articulation of data to senior leaders. The first goal centered on the physical operations at the MOUT site. The cadets were required to survey five different buildings and collect data so that a displaced personnel population to reoccupy the location. The full site survey included locating “hidden” radioactive sources, identifying the radioactive isotopes, and then determining the isotopic activity (measure of the strength of the radioactive nature of the isotope) of any isotopes located. The second goal of the laboratory was for the cadets to operate the detectors in a realistic environment and employ proper equipment techniques to include preventive maintenance checks and proper start-up procedures. Finally, the third goal required the cadets to perform a full analysis of their data (types of radioisotopes, potential uses of the radioisotopes, and potential health hazards) while conducting proper briefing techniques appropriate for a junior officer to a senior officer in the US Army (Figure 2). All three goals were derived from real experiences and have been incorporated into normal training for US Army professional health physicists. Additionally, all the senior officers and personnel receiving the briefs from the cadets at the conclusion of the exercise were able to fully articulate how they have used their own nuclear engineering knowledge and experiences in their US Army career.

Figure 2. Briefing environment required of the cadets in the field laboratory exercise.

Captain Ross Pixler (Company Tactical Officer and nuclear engineering alumnus of USMA Class of 2005) provided an additional dose of realism by driving out to Camp Shea to receive the out-briefings from each cadet team. Based on his experience in deployed tactical environments and from being an undergraduate nuclear engineering major, Captain Pixler was able to truly bring operational experience to the laboratory and his use of nuclear engineering knowledge throughout his career.

The laboratory was conducted over a six hour time interval on one single day. The cadets were fully briefed about the exercise expectations prior to the event. Therefore when the cadets, divided into three different teams, arrived at Camp Shea, from the rally point on the main campus, they were immediately expected to perform equipment checks while the team leaders received an in-brief from a notional military leader as to their mission on the site and when to deliver their final brief to other military leaders. Military training operations are often conducted within this context of in-brief, in-progress reviews, and out-brief. The team leaders were subsequently expected to further explain the mission expectations back to their team subordinates. For safety purposes, each team was assigned a cadet lane walker, who not only observed the conduct of the team but also focused on the safety of the operation. These lane walkers essentially served as the “eyes and ears” for the overall person in charge of the laboratory. Teams were expected to conduct proper survey techniques and were assessed on their ability to function as a team while adhering to appropriate safety precautions.

While out at Camp Shea, cadets were given the opportunity to develop tactics, techniques, and procedures for conducting radiation surveys in a simulated urban environment. They were determining “on-the-fly” which radiation detectors to use out of the different models of detector present (including but not limited to Berkeley Nucleonics SAM 940 Defenders, Canberra Inspector 1000, Ortec Detective, Rae Systems Gamma RAE IIR, military specification detectors

AN/VDR-2 and AN/PDR-77, WB Johnson DSM 506/502, and numerous personal dosimeters) making up the two main detector modes (current and pulse) in order to find, identify, and characterize radioactive isotopes.

The final phase of the laboratory experience for the cadets was to out-brief notional commanders on both short- and long-term health hazards of the radioactive isotopes. In this manner, the ability of the cadets to articulate the science was assessed. Cadets were able to draw many parallels from the experiences of being on a survey team to those they had gained from previous summers. Cadet Eddie Ortega-Aviles summed up the experience when he said that team cohesion is especially important and detectors are only as useful as the personnel who employ them. For this laboratory, senior nuclear engineers (both military and civilian) were asked to receive the out-briefs. Out-briefs are a very important part of Army operations and offer the cadets and senior officer the opportunity to determine the aspects of the laboratory that went correctly and those aspects of the laboratory that did not go as planned. Cadets can then build upon this knowledge and experience for similar missions at future times. Senior officers are also incredibly important in this process as they can ask the difficult questions and help cadets to translate what they learned in the laboratory to more real-life situations.

The objectives of the laboratory were fully met. Not only did the cadets get an opportunity to use a myriad of equipment in a field-type environment but they were also able to blend the Army training that they receive in other courses with their nuclear engineering classes. Twenty cadets went through the exercise in 2014 and another 17 cadets experienced the exercise in 2013. When asked if they feel as though they gained more confidence in using radiation detectors in a field environment following the Camp Shea exercise than before the exercise, the cadets responded with a resounding yes (32% agreed and 65% strongly agreed). When asked which detector type (gas-filled, scintillator, or semi-conductor) they felt most confident in using, 55% felt most confident with scintillation detectors, 32% preferred semi-conductor detectors, while only 13% preferred gas-filled detectors. When asked about his experience studying nuclear engineering CDT Taylor Richard mentioned that "nuclear engineering has allowed me to learn and gain confidence in my ability to do more than I thought I was capable of a few years ago. People need to be continually educated on the benefits of radiation as well as the hazards."

Nuclear engineering laboratories are extremely effective in a normal laboratory environment where specific detector components can be isolated and studied. The NE program is fully able to study detector components and radiation phenomenology in the classroom-style laboratory environment but the learning really comes alive when the students are taken out of the normal environment and are expected to use their knowledge in a more realistic scenario. The West Point NE program is going to continually push the envelope of this Camp Shea experience. Next year, the laboratory experience will incorporate the use of available radiation plume modeling software that can be incorporated into radiation detector simulators. Simulation technology will add even more realism to the experience while normal radioactive isotopes will continue to be used for further experience characterizing radiation sources.