# ADULT LEARNING AND NUCLEAR SECURITY

The Important Role of Adult Learning Educational
Practice for Impactful Cross-Disciplinary Nuclear
Security Training

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Abstract

The human elements of sustainable nuclear security rely on integrating the principles of adult learning into nuclear security training and exercises. Nuclear security is fundamentally cross-disciplinary, between intersecting roles of technical experts, researchers, non-technical security personnel, professional crisis communicators, and emergency responders. These communities need to be exposed to essential nuclear security topics within a training environment which allows participants to learn from one another and contribute their professional experience in the field. Adult learning principles encourage trainers and facilitators to recognize the unique traits of adult learners, draw on their experience, involve learners in the learning process, and provide space for self-driven learning. Drawing from a variety of experiences in nuclear security training supported by the Department of Energy, National Nuclear Security Administration, Office of Nuclear Incident Policy and Cooperation (NIPC), this paper explores how adult learning principles can enhance both learning outcomes and the sustainability of nuclear security training.

## Introduction

Nuclear security is a global concern at the intersection of a variety of disciplines that demands a thoughtful and tailored approach to sustainable training across the nuclear security response system, informed by the methodologies that guide adult learning. The breadth and depth of cross-sector knowledge supporting nuclear security presents an inherent sustainability challenge. Beyond the obvious contributors, such as technical experts in the nuclear sciences, plan writers, and analysts focused on nuclear security as the central mission of their profession, there are many professionals whose mandate includes nuclear security as just one of multiple areas of responsibility. At the highest level are policy makers and their supporting staff/organizations, who are responsible for codifying a nuclear security policy apparatus as only one of a variety of policy areas under their purview. Law enforcement personnel at different levels of government may include nuclear security specialists, but these are likely outnumbered by the breadth of law enforcement personnel who will serve as first responders during an evolving nuclear security incident. Other response communities, including fire, emergency medical personnel, and crisis communications also will play a role in responding to such an incident. Nuclear security, and the unique challenge of responding in a potentially radioactive environment, is a whole-community problem set.

Given the scale and scope of the nuclear security system, it is unreasonable to educate each potential responder to a nuclear security event to expert-level competency. Training periods will likely be few and far between, due to resource constraints and competing priorities of these intersecting communities. Adult learning best practices can improve learning outcomes, retention, and by extension sustainability for learners with limited nuclear security training contact.

## Adult Learning (Andragogy) in Principle

Malcolm Knowles provided the foundation for the traditional and most common understanding of andragogy in his 1968 publication, “Andragogy, not Pedagogy.”[1] Knowle’s understanding of adult learning grew out of four assumptions about the nature and state of an adult learner [2]:

1. As a person matures, his or her self-concept moves from that of a dependent personality toward one of a self-directing human being.
2. An adult accumulates a growing reservoir of experience, which is a rich resource for learning.
3. The readiness of an adult to learn is closely related to the developmental tasks of his or her social role.
4. There is a change in time perspective as a people mature – from future application of knowledge to immediacy of application. Thus, an adult is more problem centered than subject centered in learning.

These four assumptions lead Knowles to six key principles of andragogy: the learner’s self-concept, experience, readiness to learn, problem-centred orientation, internal motivation, and the need to know. Over time, Knowles and others refined their philosophy of adult learning, but while still retaining its core themes, Knowles eventually recognized that, rather than a hard distinction between the education of youths and adults, pedagogy and andragogy represent a continuum “ranging from teacher-directed to student-directed learning.”[3]

The pedagogy-andragogy distinction is the distinction between direct and indirect instruction – being told what the problem is and why it matters versus the learner having the opportunity to determine themselves why something presents a problem and how their specific actions and responsibilities matter. These self-directed characteristics of adult learning practices support contextualization and retention. Fundamentally, this paper suggests that andragogic principles are relevant to nuclear security sustainability not because the learners are adults, but rather because the training required to support nuclear security is most effective when it falls on the student-directed end of Knowles’s continuum.

Drawing upon Knowles’s six principles and his underlying assumptions about adult learners, this paper addresses adult learning through four characteristics: the unique context of adult learning, experience, process, and self-driven learning.

### Unique Context

The unique context of adult learning is primarily defined by the learner’s experiences, including past educational opportunities and significant personal and professional experiences. Education of adult audiences, especially in a training setting like the one of most concern for nuclear security sustainability, almost always builds on a foundation of existing knowledge so training content should not be looked at as something entirely new to the learner. Most adult training audiences will approach a learning opportunity with an established foundation of professional training and experiences which provide the context for nuclear security training. Context affects a learner’s readiness for learning and ownership of the learning process, including how a learner perceives future applications of the materials on which they are being trained which impacts both attention and retention [4].

### Experience

Experience as a characteristic of adult learning is different from the experiences that create the context for learning mentioned previously. Here, an “experience” refers to the type of in-class learning presented in a training course, typically as interactive opportunities that encourage creativity and critical thinking. There are two mechanisms through which experience can impact learning outcomes: reflective practice and situated cognition [5]. Reflective practice is a method of continuous learning based on reflection upon past experience. In the context of a training course, reflective practice involves not just reflection on past actions but the use of new information to assess experience, which is supported by training design that draws upon participant experience. When effective, reflective practice allows participants to situate new information in their own knowledge framework created by past professional experience and training. Situated cognition suggests that knowledge cannot be separated from environment or other factors such as activity, people, language and culture. In a training environment, “learning occurs as people interact with other people in a particular context with the tools at hand.” [6] Depending on the subject and desired learning outcomes, interactivity among trainees and with equipment or in environments directly applicable to the training subject matter can significantly improve not only learning retention but also critical thinking that ultimately expands learning outcomes.

### Process and Input

A key distinction between pedagogical and andragogical methodologies is the process of instruction. Pedagogical models will tend towards rigid structure, where organization, delivery, and assessments are determined by a teacher. Unlike most young learners, adults have both the ability and interest in being involved in their own learning process [7]. Recognizing that a certain degree of structure is essential to a well-executed training course, adult learners can engage in the delivery, planning, and especially the assessment of their own learning.

### Self-Driven Participation

The three proceeding characteristics each depend on or are related to the self-driven nature of adult education. An educational program can typically be thought of as either subject-centred or problem-centred, where the former emphasizes subject matter for its own sake and the latter emphasizes a specific problem set or capability enabled by an educational program [8]. Adult learning is typically not considered subject-centred but rather problem-centred. In the case of nuclear security training, we find that participants are less likely to be specifically interested in learning, for example, about the fundamentals of radiation and radiation health effects, and more interested in the operational or clinical challenges unique to a radiological environment that an understanding of those fundamentals will allow them to address. Focusing on the operational context and applications of radiation principles increases learner engagement, interest, and retention.

A problem-centred approach to adult learning helps create a self-driven learning environment. While adults are capable of acquiring new skills and learning new subjects, studies find that absent motivation, adult attention and interest in learning can face significant headwinds [9]. While most academic literature on andragogy refers to “self-driven” learners in some way, it is worth noting that drive can also include the flexibility for self-determination. While it can be effective and sometimes necessary for an instructor or facilitator to explicitly state the problem that a course of training is intended to address, the exact motivation for learning will differ among members of a training audience. Therefore, it is more valuable to provide the audience an opportunity to connect those dots themselves rather than basing the course solely on an instructor-determined purpose.

## The Learning Audience

Nuclear security is a highly specialized field that relies on technical experts with many years of formal education and experience supporting nuclear research and activities in support of nuclear infrastructure. While essential, these technical experts represent a comparatively small portion of a nuclear security response relative to the less specialized and more diffused response community likely to be first to the scene of an incident involving radioactive material. Nuclear security planning always and fundamentally relies on those on the ground who respond first to security events and emergencies. The priority learning audience for the principles described in this paper are non-specialized responders who rarely have the time, resources, or mission prioritization to develop expertise in nuclear security response. Figure 1 provides a rough approximation of the scope of knowledge a given segment of the nuclear security response system requires to be effective.



Figure 1: Diagram comparing response community segments and the necessary level of specialized knowledge, where the triangle on the left depicts responders in relative proportions and the inverse triangle on the right represents the scope of knowledge corresponding to each community

The top segment of the triangle to the left represents the technical experts who provide the primary knowledge base for nuclear security, represented by the largest segment in the inverse triangle to the right. These technical experts may also be the instructors and facilitators crafting the training programs for the rest of the response community addressed in this paper. Technical experts include not only scientific expertise but also policy and planning expertise that sustain the nuclear security system. Those represented in this smallest segment of the community have nuclear security as their primary or singular focus in their mission space, and therefore have the education and mandate to sustain their advanced level of knowledge.

The middle segment in both triangles represents specialized responders. In the United States, the quintessential example is the Weapons of Mass Destruction Civil Support Teams (CST) of the National Guard, with at least one CST established in each state and territory of the United States, and some larger states requiring two teams. Each CST includes roughly 20 full-time personnel filling roles in command, operations, logistics, medical/analytical, communications, and survey. The CST mission space includes the full chemical, biological, radiological, and nuclear (CBRN) spectrum. This middle category is less clearly defined as those above and below it and will vary depending on the resources of a country or region, with some teams falling into to the technical experts category, and others more closely aligning to the general response community. For an example near the high end of the specialized category, consider the Radiological Assistance Program (RAP) in the United States, which includes eight specialized response teams distributed across the country with assets and technical expertise specific to incidents involving radioactive material. Closer to the lower end of specialized response category are Hazardous Materials Response (HAZMAT) teams, which are more broadly trained to respond to incidents involving any material considered potentially hazardous, not only CBRN/WMD. In the United States these teams are frequently associated with fire departments at the local government level, so they are more numerous than CSTs and RAP teams and also may vary in terms of resources and training.

The “broad response community” that forms the base of the triangle at the left of Figure 1, as well as the base of the response community in the United States, is the primary learning audience of concern. This is not to suggest that adult learning techniques are not applicable for technical experts and specialized response teams, but that they are less essential to the success of those two communities given their mission and mandate to sustain knowledge, skills, and resources specific to nuclear security incident response. The broad response community includes police officers, firefighters, emergency medical technicians, paramedics, and others. In the United States, 2.2 million is a conservative estimate of the number of responders who fall into this category. It is important to also consider security personnel working at facilities using radiological or nuclear material who may receive varying degrees of specialized training depending on the facility. Beyond these groups are professional communicators, customs and border control, logistics professionals, and other communities that may encounter nuclear or radiological hazards in their professional capacity.

There are three essential traits about the general response community to keep in mind. First, these responders will always be first to the scene during an incident involving radioactive materials. Specialized teams, trained and equipped to operate in hazardous environments, will only be deployed to an incident when there is reason to suspect the presence of hazardous materials. Until this determination is made, it is the responsibility of first responders to manage the scene. The decisions these first responders make in the first moments of an incident will have significant implications for community protection and the long-term success of a response operation.

Second, despite the important role first responders play in initiating and supporting nuclear security response, there are insufficient resources available to train the broader response community the same way specialized teams can be trained. Additionally, the mission scope and mandate of the broader response community is such that they will not tend to have time available for anything beyond brief training courses on niche problem sets like nuclear security.

Third, and most importantly from a training perspective, first responders already receive substantial training to support their function in a response operation and the day-to-day requirements of their positions. Much of their existing training is applicable to their role in nuclear security response and only needs to be added to or slightly modified to significantly improve their ability to operate safely in a potentially contaminated or irradiated environment.

## Application

Based on the characteristics and techniques of adult learning and the target learning audience for nuclear security, there are four recommended actions for those responsible for developing or overseeing nuclear security training programs.

### Use limited time wisely

The general response community has limited bandwidth for niche training, so instructors addressing the nuclear security problem set will likely have limited contact time. Based on the problem-oriented nature of adult learners, it is essential that instructors and facilitators select their training material wisely. There is a temptation when presented with limited time to compress as much information into a lecture format as possible, but course content should be neatly tailored to the specific operational needs of a given learning audience. Information that does not directly address the operational realities of the learning audience and their problem-oriented perspective are at best of limited value, and can be actively counterproductive to the desired learning outcomes of a training program by diluting course content with non-essential information and distracting learning from priority objectives.

### Communicate and contextualize the threat

To build motivation among a particular learning audience, a training course should explicitly state the nuclear security threat the course is designed to address to ground learners in the same frame of reference as the instructor. Additionally, the course should also help learners identify threats on their own, either in addition to those outlined by the instructor, or more specific contextualized threats relevant to the locality and operational environment a particular learning audience understands. A clearly understood threat serves as the focal point for problem-oriented learning and will drive learning outcomes. Additionally, appreciation of the threat is a valuable training outcome in its own right, particularly when a learning audience includes decision makers who may have authority over training resources.

### Research training and standard operating procedures of the training audience

A typical and understandable perspective in any course of instruction is that the instructor is the primary, if not singular source of information for training. However, a central principle of adult learning is that it should be assumed that an adult learning audience will bring significant training and experience to the course that ultimately makes up a non-trivial portion of the learning content of a training program as participants discuss training topics and learn from each other. The onus is on the instructors to familiarize themselves with the existing training and operational environment of the learning audience so the training course can be tailored to more effective integrate nuclear security-specific information into an existing training foundation. In addition to more effectively contextualizing training materials, this step can help instructors recognize areas of overlap where existing practices can serve nuclear security purposes and do not need to be presented as something entirely new. For instance, when training a law enforcement community, it is possible that they are trained to approach a potentially hazardous or threatening situation using principles that mirror the “time, distance, and shielding” best practices the nuclear security community relies on. For the medical community - both first responders and physicians - the practices used to minimize the risk of biohazard contamination in protecting both patients and medical staff are largely effective in reducing the risk of contamination when managing an incident involving radioactive materials. Trainers should do their utmost to identify and integrate existing training and standard operating procedures into their course of instruction, recognizing these details may differ between audiences.

### Create collaboration

Interaction and collaboration in a course of training are essential tools in support of learning outcomes and retention. Do not look at a collaborative activity as a break from learning because the information is not presented in a lecture format. Given the opportunity, participants will learn from each other and discover new lessons no instructor could have provided, because some valuable training outcomes will be unique to a particular operational setting and a participant’s lifetime of experience. Collaborative activities provide decentralized learning opportunities, which can be uncomfortable for instructors and facilitators, but should be embraced. In most training environments it can be challenging to break free from a rigid classroom format, but the bar does not have to be set at the level of a field exercise or drill. Proxies and more tailored and focused activities can be created as a compromise that still provide valuable learning context.

The integration of collaborative activities in a training course is often easier said than done, so examples from work conducted by the U.S. Department of Energy, National Nuclear Security Administration, Office of Nuclear Incident Policy and Cooperation (NIPC) may provide some simple examples for reference. An increasingly commonplace example is the use of a tabletop exercise (TTX) to encourage discussion collaboration during training. In training conducted as part of a course designed to train customs and border control authorities to identify CBRN materials, a multi-hour TTX provides the opportunity for a multiagency group to discuss assets and coordination that support the problem set highlighted in the course. The TTX is designed to confront participants with the specific topics addressed by course instructors but in a local context.

Traditional TTXs are not always ideal learning tools for training courses because they more naturally support discussion of interagency coordination and policy and planning challenges. However, the NIPC team has found that the addition of more tactical elements in a scenario-based, collaborative activity can support operational and tactical activities that support more operational course content. In the same customs and border control course mentioned above, the NIPC team used cards with different equipment or resources and point values. Participants were instructed to select cards in response to a simple escalating scenario and were provided a specific point value they could not exceed with their selected resources. This activity enhanced participant collaboration due to the need to explain and discuss the application of particular types of specialized equipment to different operational settings, a topic fundamental to the training course. In a different course focused on nuclear security in a maritime setting, participants were provided a simplified map of the area highlighted in the scenario in addition to the cards, and encouraged to not only consider how specific equipment should be deployed but also how environmental elements may impact that decision making process.

Straying farther from the traditional TTX model, a training course conducted in the United States with local first responders addressed more tactical elements of nuclear security response. A diagram of a room on a grid with walls of varying thickness and composition was projected on a screen in front of the training audience. The facilitator identified a particular radioactive source placed somewhere in the room and provided additional operational considerations, such as casualties in need of medical treatment. Participants applied their understanding of radiation fundamentals and protective actions from the course to resolve a series of simple problems. Each of these activities was tailored to the specific learning audience and built to reinforce other training materials and overall training objectives.

## Conclusion

An effective, timely, and sustainable nuclear security response capability depends on the diffusion of nuclear security principles and practices among a broad range of relevant disciplines, not just a specialized few. Adult learning principles are intended to support learner engagement and retention and are effective when applied with limited contact time, which is necessary considering the scale of contributors to nuclear security response. Four characteristics of the adult learner should inform course design, including: the unique context of the adult learner, informed by their lived experience and educational history; the importance of the in-class experience in providing learning opportunities that build on a learners experience; the desire of most adult learners to be active participants in the instruction and assessment process; and the self-driven, problem-oriented perspective of most adult learners. Based on these characteristics and an understanding of the nuclear security learning audience, instructors and facilitators should maximize effective contact time by reducing superfluous information, communicate and contextualize nuclear security threats to focus problem-oriented learners, research training and standard operating procedures of the learning audience to maximize cohesion between the nuclear security training and foundational training already in place, and create collaborative opportunities that allow participants to learn from each other and expand the audience-specific learning outcomes of the training course. Effectively integrated adult learning principles in nuclear security training can improve overall learning outcomes and enhance the sustainability of a nuclear security system.

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