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APPLYING IMMERSIVE LEARNING METHODOLOGIES TO THE SAFETY AND SECURITY INTERFACE PARADIGM FOR NORMAL COMMERCIAL SHIPMENTS OF RADIOACTIVE MATERIAL

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ABSTRACT

During a series of consultancy meetings at the International Atomic Energy Agency (IAEA) to develop a technical document that assists in the interface between safety and security in the transport of radioactive material, it was determined that, in addition to the IAEA Technical Report (TRS No. 1001), workshop content would be developed to ensure that knowledge would be transferred. By using the systematic approach to training and immersive learning methodologies, the IAEA will provide a technical report and workshop content to Member States.

The workshop will be designed using 3D modeling to ensure that workshop participants are actively engaged in the learning process by being immersed in realistic scenarios. Workshop participants will utilize the 3D model to assess and evaluate aspects of transport security. By using the 3D model as the basis for learning, the use of PowerPoint slides will be reduced. In this approach, workshop participants will be encouraged to interact early in the workshop and will be partnered with other participants, so they learn from each other as well as the instructors. The 3D model will be provided to each workshop participant so that they can share with others and continue their learning experience after they complete the workshop. A separate paper will outline the workshop materials developed to date.

INTRODUCTION

Historically, nuclear regulations have emphasized the safety[1] of the storage, use, and transport of radioactive materials. Safety regulations have been in existence for more than 50 years (1961). Topical areas of these safety regulations have included training requirements, quality assurance, radiation limits, and packaging requirements.

Safety was also the basis for most transport regulations within the international community. As a result of decades of safety regulation infrastructure, rigorous package certification and training programs were developed and implemented. These programs coupled with sound inspection and training practices have led to a very stellar safety record for the transport of radioactive material and spent nuclear fuel.

However, following the unprecedented attacks on September 11, 2001, the international community recognized a responsibility to develop guidance to assist Member States in the implementation of adequate security for materials in transport. The IAEA developed working groups focused on transport security, and one of the results was the Nuclear Security Series (NSS) documents for Transport Security including:

- NSS 9 "Security in the Transport of Radioactive Material" issued in 2008,
- NSS 26-G "Security of Nuclear Material in Transport" issued in 2015,
- NSS 13 "Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities" issued in 2011, and
- NSS 14 "Nuclear Security Recommendations on Radioactive Material and Associated Facilities" issued in 2011.

Building upon that history, and with the events of September 11th, the international community looks to continue safely and securely handling radioactive materials. The IAEA Specific Safety Requirements "Regulations for the Safe Transport of Radioactive Material (SSR-6 Rev.1) was issued in 2012. Many Member State transport regulations focus on safety, and only in recent years have started recognizing the importance of including a security focus, too.

As Member States adopt security considerations for the transport of radioactive material, integrating safety and security, there is a need to understand the differences and crossover between the two. For example, an area where safety and security may conflict is placarding. Placarding serves a significant role in communicating and conveying to responders what a shipment involves, identification of contents, the radionuclide, the radioactivity, etc. Although placarding is required and provides standardization to Class 7 international shipments, placarding can pose a security risk, drawing unwanted attention to materials that adversaries could use for malicious intent. Such adversaries may not otherwise know where to locate this material.

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[1] For the purposes of this paper, **safety** is defined as protecting people and the environment from harm caused by radioactive materials or ionizing radiation. **Security** is defined as protecting the source or material, from people who may want to use it for malicious purposes.

Conversely, any security enhancement placed on the conveyance should not hinder safety requirements.

However, safety and security can also complement each other. For example, some Type B packages are very robust, providing the security function delay (Figure 1). While delay was not the original intent behind the package design, these types of packages will slow an adversary, given they are built to withstand the rigor of accidents (testing includes 9m drop test, immersion, fire, etc.).

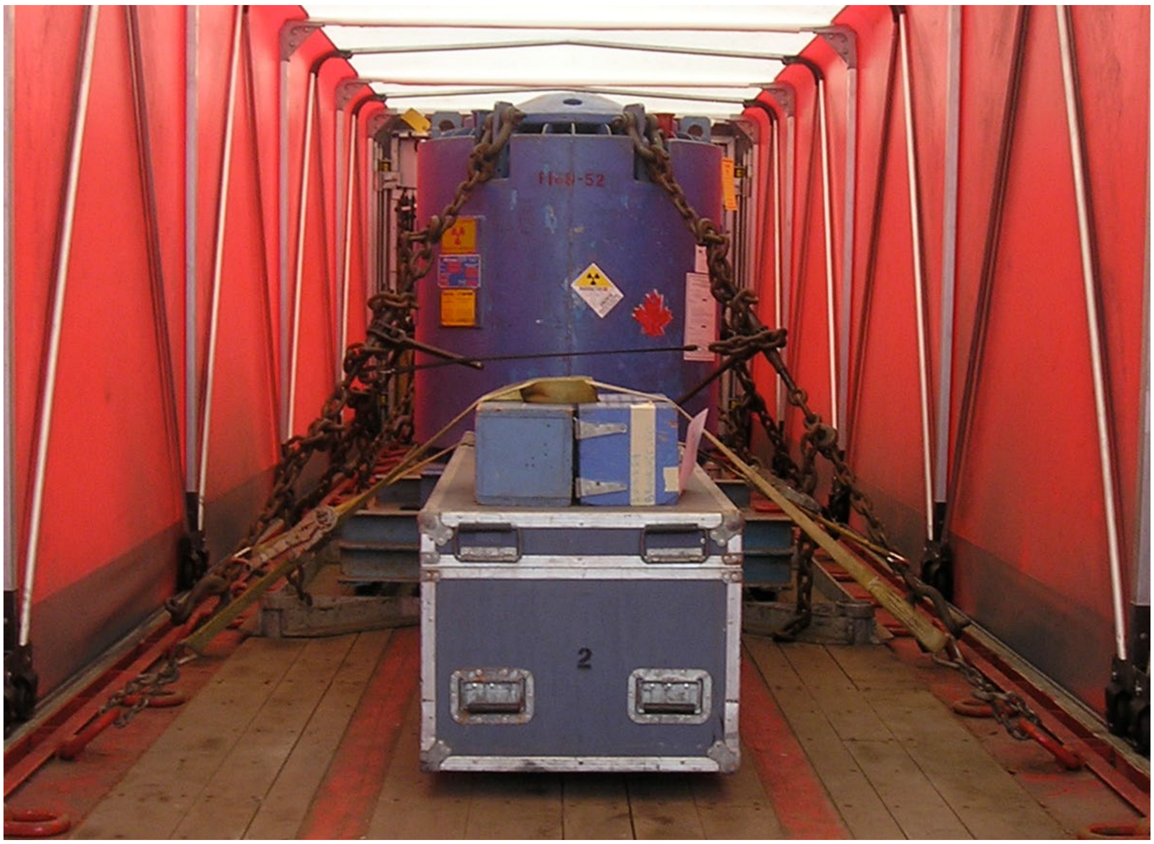

Figure 1 Type B package showing safety and security features (robustness and delay).

Understanding the differences and crossover between safety and security is an essential component of building effective training programs. This working knowledge is necessary to enable resolution of conflicts between safety requirements and any physical protection or security enhancements of the systems for which training is designed. Immersive learning methodologies can be effectively applied to many aspects of the lifecycle of radioactive material to understand the nuances that apply to both safety and security.

The IAEA recently tasked a consultancy team with producing a technical report to disseminate guidelines specific to the safety and security interface. Concurrently, a workshop is being developed to reinforce these guidelines through immersive learning approaches for international audiences. One approach uses 3D modeling in conjunction with battleboard-type scenarios to engage participants in meaningful learning that increases recall and knowledge transfer (level 2 and level 3 learning) (Kirkpatrick, 1996). Battleboard-type scenarios are facilitated by subject matter experts who engage participants with discussions and shipping scenarios focused on transport security for radioactive material. Participants play different roles (e.g. regulators, licensees, protective force, response force, technical personnel, management, hospital security, radiation safety officer, etc.) so that they learn about coordination of communication, regulatory structure, national oversight, physical protection systems, response, and training for transport security for radioactive material. The scenarios are represented by two teams (protective force and adversary), game pieces, and aerial Google maps printed to scale. 3D modeling is used to give participants an onscreen visual of the shipping scenario and the impacts of different decisions participants make. The 3D models are left behind for participants.

Several key benefits of this approach include:

- Demonstrate the differences and crossover between safety and security;
- Provide a tangible takeaway for partner countries that helps sustain continuity of knowledge;
- Increase breadth of knowledge transfer through the use of narrative arcs, collaborative learning, and by mimicking real-life environment as much as possible; and
- Reduce dependence on PowerPoint presentations in learning environments.

Moreover, in the international transport space, it should be noted that safety and security are the same word in multiple IAEA languages including Chinese, Russian, Spanish, and others. This conundrum can pose a significant challenge in addressing the nuances of the identification of safety accidents versus malicious events or sabotage involving radioactive material.

BACKGROUND

An IAEA Technical Report was drafted based on multiple consultancy meetings at the IAEA. The objective of the technical report is to provide technical advice and practical information to those in the nuclear security discipline. It provides information to its reader that will assist in the protection of radioactive material.

After multiple consultancy meetings were conducted for the drafting of the document, an instructional design team was added to the consultancy meetings. The addition of the instructional design team allowed for a path forward in developing workshop material. During the consultancy meeting, experts were split into two teams. One team continued to draft the technical report while the other team started the development of the workshop material.

During the consultancy meetings, the experts participated in facilitated knowledge gathering exercises. By using mapping exercises in the initial discussion of the workshop, the instructional design team was able to develop a list of requirements for the workshop.

As a result of the technical report, it was determined that a classroom workshop would help to further the knowledge of nuclear safety and security experts in Member States. In addition, the workshop would provide opportunities for those working in this discipline to come together and discuss challenges and successes. A workshop would also provide opportunity for learning.

This drove the approach of segregating the experts into two teams. One team worked on the development of the document while the other team developed the workshop material. Workshop material was derived from the technical report.

USING SAT TO IDENTIFY IMMERSIVE LEARNING METHODOLOGIES

The IAEA uses a Systematic Approach to Training (SAT) for developing training programs and materials to impact on-the-job performance and, in turn, organizational outcomes. The methodology consists of five phases: analysis, design, development, implementation, and evaluation. The process moves in a logical progression, each phase building on the work of the previous, with evaluation and iteration built in to achieve desired results.

Analysis

The analysis phase seeks to confirm a learning need. Organizations must identify their mission and goals, then analyze what people must do to attain that goal. The purpose of training is to support existing behaviors or direct behavior change where needed. When people are not performing the expected behaviors, a formal analysis can determine why. The first step is to identify job roles and the tasks associated with performing each specific job to the expected standard. There may be some overlap in how different jobs support an organization's mission, however, each job has unique tasks that must be performed. It is through analyzing the specific tasks of each job that gaps in performance can be identified, and then the appropriate training can be developed and delivered to support the people who satisfy those roles.

Common areas to analyze include knowledge, skills, attitude, and environment. Frequency, difficulty, and importance of tasks in these areas may also be taken into account.

Knowledge includes information that is relevant to make decisions and accurately perform tasks specific to job role and function. Knowledge may range from understanding concepts in order to make on-the-job decisions to knowing regulations that must be applied on-the-job in order to maintain a safe and secure working environment. It should be determined what knowledge must be learned and recalled from memory, as compared to knowledge which may be referenced in resources such as job aids when appropriate.

Skills are the observable, physical behaviors demonstrated on the job. Proper performance of skills is essential to achieving the mission of the organization. Training may be conducted to introduce new skills, reinforce critical skills, or correct improper performance.

Attitude is the perspective each person carries with them on the job every day. It is tied to a person's motivation to carry out the organization's mission and see how their actions fit with the big picture. Attitude can be influenced through emotional experiences that strengthen a person's resolve to support the mission or be intrinsically motivated. It may also be influenced by extrinsic motivators such as incentives and recognition within the organization.

Environment impacts the ability to perform job functions. Environment includes a variety of areas such as organizational culture, regulations, procedures, as well as access to equipment, tools, and supplies. If it is determined that environmental elements are lacking or missing, it may be determined that training is not the best solution. Using SAT to analyze and determine the cause of performance gaps may also reveal areas that require solutions other than training.

Design

Based on confirmed training needs, curriculum is determined in the design phase. Topics are sequenced and objectives are written from the knowledge and skill-based tasks identified during the analysis. Decisions are made about the type of training that is needed and how it will be built. Typically, this impacts the selection of the modality for instruction which may include instructor-led training (ILT), on-the-job training (OJT), or eLearning (eL). It may also include instructional materials that can be used during training or as job aids in the field. Examples include slides, training workbooks, manuals, procedures, supplemental videos, and quick reference guides or posters.

3D modeling presents an opportunity to design scenarios with an immersive approach. 3D modeling can lend itself to collaborative activities and discussions in the classroom, be viewed on a large screen for the whole class, on tablets such as iPads in small groups, or for use in individual, self-paced eLearning. In addition, 3D modeling has potential to also be built into augmented reality (AR) or virtual reality (VR) platforms, again as part of a course or for revisiting as a job aid.

Design decisions may be impacted by factors external to the job task. Considerations may include resources such as budget, access to an instructional design team, and subject matter experts (SMEs); as well as the development schedule, expected longevity of training materials, and adaptability of materials for multiple audiences.

At the core of this phase is designing content that is learner-centered and addresses the tasks that have been identified as essential to successfully performing the job. When properly designed, training and supplemental materials result in trainees demonstrating knowledge and skills through observable behavior. Designing thoughtful learning experiences empowers people to act once they return to their jobs.

Development

The design plan serves as a blueprint for building all training materials in the development phase. Development takes strong project management in order to produce strong, instructionally-sound training. The instructional design team must work closely with SMEs to ensure technical accuracy in writing training materials. Creativity and an understanding of adult learning principles are required when developing curriculum to support behavior change. Additionally, building supplemental materials requires clear communication among the team to ensure that materials are properly aligned with the written objectives. Developing media such as 3D models can serve as valuable assets. Depending on the design, it is possible that the development of materials that may be useable across modules and courses within a discipline.

Reliability and validity of training materials is critical. Training development requires reviews among the development team, and when possible, a dry run and pilot program to finalize materials before introducing them to trainees.

<u>Implementation</u>

The implementation phase is when everything comes together in a training event, whether that be ILT, OJT or eL. Coordination is required for implementing each training modality.

Instructor-led training (ILT) typically occurs in a classroom or at a field training site and is a face-to-face event. ILT requires the properly selected participants (i.e. those who will be performing the job tasks associated with the curriculum), qualified instructors, a training facility with the required equipment to support the delivery of materials as designed (projector/screen, flip charts/markers, wi-fi, etc.), and all required training materials (printed training guides, handouts, job aids, videos, 3D models, as well as physical equipment and/or instruments).

On-the-job training (OJT) occurs in the work environment and requires an employee to perform the identified job tasks, a qualified instructor to provide instruction (typically a co-worker or supervisor), and a qualified observer to confirm and validate training (typically another co-worker or supervisor). OJT also requires the use of systematically prepared training materials.

eLearning (eL) can be accessed from computers, tablets, or mobile phones. It is typically designed and developed as self-paced training for use by individuals. The use of audio may be included so access to speakers or headphones may be a technical requirement. Supplemental resources like manuals or job aids may be included for use outside the eL. eL can be an effective method of training delivery when it includes simulations or scenarios that allows the trainee practical application of knowledge or skills presented.

When possible, the learning environment should mimic the authentic job environment. The most important transfer factor according to researcher E.L. Thorndike. This allows for the knowledge and skills from training to have applicable behavior transfer when on the job. If the actual environment is not available, tools like 3D models can be designed, developed, and implemented to support the objectives of the training.

<u>Evaluation</u>

Evaluation is continuous throughout each phase of SAT. It is important to adjust during the process in order to deliver quality material to the trainee who needs it in order to successfully perform job tasks, and in turn support the mission of their organization. After training has been implemented, evaluation is the final phase of SAT. The Kirkpatrick Model has four levels of evaluation and is the most commonly used method to determine the impact of training.

Kirkpatrick Level 1 evaluates trainee reaction. Methods such as surveys or questionnaires capture perceptions of the usefulness of the training and whether there are areas for improvement.

Kirkpatrick Level 2 evaluates trainee learning. Various methods may be used to find evidence of learning. Formative assessments such as activities, knowledge checks, and discussions may occur during the course. Summative assessments such as written exams, formal presentations, and demonstrations evaluated by performance checklists may be used to determine whether learning took place and to what degree.

Kirkpatrick Level 3 evaluates behavior change. After trainees have returned to their jobs, follow up observations, surveys, or interviews with supervisors may be conducted and reported back to the training team. Use of these methods seeks to document whether the training influenced or changed the performance of job tasks.

Kirkpatrick Level 4 evaluates organizational results. Stakeholders have expectations about how strategic benchmarks are met in order to support the mission. Behaviors of employees ultimately roll up into the success of their organization. Desired outcomes should align with the statement of purpose. Methods for documenting outcomes may appear as metrics found in annual reports or industry research.

The findings of each of these evaluation levels cycles back into the first phase of SAT. By conducting evaluation at four levels, information gathered can be used to update or revise materials. Revealing the strengths and weaknesses of training through a formal evaluation process can prove an important task. By striving to strengthen training materials, an investment is being made in people and the organization.

Summary of SAT

An iterative approach is fundamental to the SAT process. Analysis confirms the training need, training materials are designed and developed to support the acquisition of new knowledge and skills, training is implemented in a way that is accessible and relevant to trainees, then evaluation is conducted to determine whether learning occurred, was used on the job, and impacted the mission of the organization. Feedback impacts the cyclical nature of this process to change as organizations grow and evolve.

SUMMARY

The IAEA is developing a workshop to reinforce guidelines in an upcoming TECDOC on the safety and security interface for radioactive material transport. The workshop is being developed through the Systematic Approach to Learning, using immersive learning approaches to engage international audiences from a range of nuclear-related professions (regulators, licensees, protective force, response force, technical personnel, management, etc.). Specifically, the workshop uses 3D modeling in conjunction with battleboard-type scenarios to engage participants in meaningful learning that increases in knowledge transfer and recall.

Several key benefits of this approach include:

- Demonstrate the differences and crossover between safety and security;
- Provide a tangible takeaway for partner countries that helps sustain continuity of knowledge;
- Increase breadth of knowledge transfer through the use of narrative arcs, collaborative learning, and by mimicking real-life environment as much as possible; and
- Reduce dependence on PowerPoint presentations in learning environments.

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