AC 2008-182: TECHNICAL COLLEGE PROGRAM IN RADIATION PROTECTION

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Technical College Program in Radiation Protection

Need for radiation protection technician degree program

The University of Missouri – Columbia was awarded a US Department of Labor grant (# HG-15355-06) under the President's High Job Growth Training Initiative for the energy sector with the objective of developing and disseminating an Associates of Applied Science Degree in Nuclear Technology (AASDNT). A primary goal of this curriculum development effort is to support manpower needs of the nuclear energy industry for RPTs. Such a program is needed in the field of radiological safety to contribute to meeting the growing need for qualified, skilled workers throughout the USA. Loss of RPTs at nuclear power plants will exceed 57% over the next five years, and over 1,000 replacement radiation protection workers will be needed. This does not include the needs at the US Department of Energy or the impact due to the creation of new jobs from new nuclear power plant construction. Indeed, recent reports show a need for roughly 90,000 new nuclear employees in the next 10 years. The RPT curriculum will prepare new RPTs to take the places of current radiation protection staff transitioning into retirement.

RPT curriculum overview

The RPT curriculum that we have designed focuses on task-oriented knowledge acquisition in contexts that support authentic learning. The curriculum consists of a six-course sequence (see Appendix) that will be implemented at five community colleges throughout the nation (Linn State Technical College in Missouri, MiraCosta College in California, Hill College in Texas, Estrella Mountain Community College in Arizona, and Central Virginia Community College). This six-course sequence constitutes the core radiation protection curriculum for the degree. In addition to these core courses, learners are required to complete an additional fifteen to eighteen courses to fulfill the requirements for the Associate of Applied Science degree. Furthermore, learners will complete a required internship between their freshman and sophomore years at a nuclear power plant. Each technical college is partnering with a nearby nuclear facility in order to provide authentic internship experiences for the learners.

The core curriculum structure of six courses has been designed to provide learners with an appropriate breadth and depth of knowledge and skills to prepare them for a career in radiological safety. The introductory courses will provide learners with the physical and chemical foundations of radiation, including descriptions of numerous different applications of radiation. The remaining courses are organized according to the kinds of tasks that RPTs perform. The first two courses were implemented in the five partner schools during the 2007 academic year, and the remaining courses will be implemented during 2008. Thereafter, they will be offered on a rotating basis at each of the community colleges.

Each course presents scenarios in which RPTs will be monitoring and protecting other personnel from sources of radiation. These scenarios are embedded in various contexts in which there is a need for ensuring radiological safety, including nuclear power plants, research reactors, hospitals, isotope production facilities, etc. Every scenario is supported by all relevant regulations and guidelines (NRC, DOE, DOT, ANSI, INPO), procedures for each activity, supporting cases of operating experience and event reports, descriptions of the radiation sciences, situational awareness (self- and peer-checking) procedures, and advice from others. These scenarios may be used by course instructors in numerous ways, from the objects of lectures to problem-based learning. Utilizing a blended learning format, learners concurrently approach course content and relevant scenarios both in class and online. We provide training and manuals for faculty members on these alternative pedagogies using the materials that we have developed.

Front-end analyses and findings

The six-course core curriculum was extrapolated based on the results of comprehensive needs and contextual analyses at a number of varied nuclear facilities (nuclear power generation plants, research reactors, isotope production facilities, nuclear medicine facilities). We conducted contextual analyses to elucidate the various cultures and contexts in which radiation protection work takes place and how these impact RPT activities. We performed needs analyses to determine what tasks RPTs regularly perform, to establish optimal instructional strategies for RPTs, and to determine any deficiencies in extant models of RPT instruction. Our analyses and findings are discussed in the following sections.

Needs and contextual analyses

We performed contextual and needs analyses to determine the nature of the work an RPT performs as well as to inform the design of the RPT academic program. The most common kind of needs analysis for determining curricular requirements identifies the topics or concepts that graduates should know when they have completed the instructional program. More traditional topic-oriented curricula typically result in learning objectives that emphasize recall of concepts. For example, as part of our needs analysis, we analyzed Department of Energy (DOE) and Institute of Nuclear Power Operations' (INPO) RPT training objectives. Our analysis showed that, of all learning objectives, 60% focused on memorization, 18% on comprehension of ideas, 18% on application, 3% on analysis, and less than 1% on evaluation of knowledge. Our analysis of the kind of knowledge required by these objectives showed that 52% focused on factual knowledge, 21% on conceptual knowledge, 27% on procedural knowledge, and less than 1% on meta-cognitive knowledge. Our needs analysis also showed that the nuclear industry is probably the most highly regulated in the world, with extensive rules and guidelines provided by the Department of Energy, Nuclear Regulatory Commission, and numerous other task-specific agencies. Given the highly regulated nature of the industry, accountability is essential to these organizations, as well it should be. However, too often accountability is associated with memorization because memorization is the easiest and most reliable form of assessment. Given the complexity of the tasks that RPTs regularly perform and the importance of their performance to the safety of workers potentially exposed to radioactive sources, memorization is insufficient for their preparation. In this light, the ability to perform numerous problem-solving tasks is essential to job success. Hence, in order to assess performance needs, we needed a more robust form of analysis for articulating the curriculum.

Therefore, our needs analysis began with the assumption that we must identify what tasks RPTs perform. Knowing what they regularly do in different contexts is key to determining what they must know and how they must implement various methods. Thus, we needed to analyze the activity systems in which RPTs perform radiation protection tasks. The most robust method of analysis for analyzing workplace activity systems is activity analysis (Jonassen; Tessmer; Hannum; 1999). Rather than focusing on knowledge states, activity theory focuses on the activities in which people are engaged, the nature of the tools they use in those activities, the social and contextual relationships among the collaborators in those activities, the goals and intentions of those activities, and the objects or outcomes of those activities. Activity theory creates a framework for the instructional designer to assess tasks within the context in which they occur. Activity theory focuses on the interaction of human activity and consciousness (the human mind as whole) within its relevant environmental context. According to activity theory, the unit of analysis is an activity. The components of any activity are organized into activity systems (Engeström 1987). RPTs regularly perform activities such as assessing potential exposure and establishing safety perimeters around potential radiation sources or sources of contamination. Those activities require a number of actions, such as operating a detector to determine exposure, calculating exposure limits, remaining cognizant of procedure adherence, and maintaining situational awareness (e.g., peer- and self-checking). Those actions vary depending on the context in which they are performed (e.g., hospital, nuclear power plant). In those different contexts, the actions are mediated by the use of different tools, regulated by different agencies, or subject to different divisions of labor in the context. We focused on identifying what RPTs do in their jobs by observing and interviewing experienced RPTs in different settings, ascertaining the regulatory standards in those contexts, site-specific procedures and documentation.

To perform the activity analysis, we met with radiation protection personnel and health physicists to clarify the purposes of RPTs. We conducted our activity analysis by observing and interviewing RPTs and health physicists in nuclear power plants, hospitals, a research reactor, and research centers using radioactive sources. For each of the activities, we analyzed the component skills (actions and operations) involved in completing the activity. For each activity, we identified the roles of the RPTs (the subject of the activity system) and the communities in which they work. Those communities vary quite a bit. For instance, a RPT in a research center must work with a very different clientele (in terms of background knowledge and skills) than a RPT in a power plant. Those workers also manifest different attitudes toward radiation issues, in part because of the inherent radiation risks in their jobs. We also identified the tools they used to perform the activities and the rules that circumscribe performance. The tools involve different detection meters and dosimetry equipment. The rules that describe acceptable processes also vary. These include Department of Energy regulations, such as 10CFR20, but also Nuclear Regulatory Commission regulations and guidelines from industry associations such as INPO. We also tried to identify the socio-historic differences in the contexts in which RPTs operate. In addition to various rules, different radiation contexts also exhibit different cultures, based on the origins and experiences of the workers and the supervisory staff. For example, a great many workers in power plants come from the Navy nuclear program, so they bring a military perspective to their operations. Those socio-historical differences have significant impact on how jobs are perceived and conducted. Finally, we attempted to recognize any contradictions that were inherent in the activity systems we identified such as contradictions among regulations provided by different agencies, contradictions among the tasks that are performed, or contradictions among the roles that are assumed by different personnel (RPTs, health physicists, operators, etc.). The purpose of activity analysis is to articulate the nature of human activities in all of their contextual richness, realizing that the same jobs performed in different contexts may appear and function quite differently. Because the goal of the project is to prepare RPTs to work in a variety of contexts, these ecological issues are extremely important in preparing RPTs to work in different contexts.

Knowledge and skills associated with radiation protection work

Based on our analysis, we identified a set of tasks that RPTs regularly perform (Table 1). The ability to perform these tasks requires a significant repertoire of knowledge and skills.

- Performing airborne radioactivity surveys
- Inventorying radioactive materials
- Monitoring radiation fields
- Responding to emergencies
- Writing procedures to describe tasks
- Monitoring personnel for internal and external radioactive contamination
- Performing radiological decontamination of areas and equipment
- Maintaining radioactive survey instruments
- Calibrating radiation survey instruments
- Preparing radioactive materials for transportation
- Performing surveys of material and equipment for unconditional release of radioactive sources
- Monitoring internal and external exposure of personnel to ionizing radiation
- Disposing of radioactive high-level and low-level waste materials
- Providing radiological coverage of jobs and high-risk and low-risk activities (e.g. outages)
- Identifying and responding to abnormal and emergency radiological conditions
- Ensuring radiation detection instrument operability
- Storing radioactive materials

Table 1. *Regularly-performed radiation protection technician duties*

Results of Front-End Analysis

The results of our analysis of Department of Energy (DOE) and Institute of Nuclear Power Operations' (INPO) ACAD RPT training objectives indicated that extant models for RPT instruction focus predominantly on memorization of facts, with some attention given to understanding and application of concepts and procedures. However, as we discovered from our contextual and task analyses, the full breadth of knowledge and skills required for an RPT to effectively perform his or her job encompasses a much broader spectrum than this. Higher-order knowledge and cognition that includes analysis and evaluation is applied regularly in RPT work. In order to ensure the radiological safety of workers and their work environment, RPTs must possess highly complex and contextualized problem-solving abilities, and they must be able to transfer the knowledge and skills associated with these problem solving abilities to new and sometimes disparate work contexts. Based on this, we concluded that existing frameworks for RPT education do not fully incorporate the breadth and depth of knowledge and skills comprised in RPT work. This belief is supported by Dauer and StGermain's (2006) assertion that traditional approaches to radiological training may not be enough to facilitate deep learning. They warn that adherence to traditional educational approaches may result in workers with knowledge and skills deficits. They encourage the exploration and evaluation of alternative learning philosophies that use such learning strategies as: inductive discussion, self assessments, case studies, demonstrations, projects, prompting and coaching, interactive lectures, and guided reflection. We have attempted to incorporate many of these strategies into our theoretical and instructional design framework to address the gap we identified in extant models for RPT training and education and to promote higher-order thinking and knowledge generalization.

Theoretical framework for radiation protection technician training

The overarching goal of our curricular design is to promote higher-order cognition and knowledge generalization (transfer). It is our belief that moving beyond extant education models toward those that encourage development of higher levels of cognition will address the deficiencies of current instructional models for RPTs and will improve performance in actual application of knowledge. In the proceeding sections we provide the theoretical framework used to forward the learning goals of the curriculum and discuss how this theoretical framework is realized in our instructional design.

Case-Based Learning

In essence, a case is a story. Cases attempt to offer a realistic account of events and/or problems, thus providing a means by which learners can vicariously experience the complexity and uncertainty of the real world. Teaching with cases is a widely utilized instructional strategy in many domains, including medicine, business, and teacher education. Cases integrate learning, memory, and reasoning by focusing on the concrete rather than the abstract (Kolodner 1993) while providing a context for learning and representing experience in a narrative format (Schank; Fano; Bell; Jona 1993). For example, as opposed to teaching about how one goes about collecting items from a list in a grocery store and then paying for them at the checkout counter, case-based learning would provide the learner with a story (case) of how someone actually performed the task, their subsequent success or failure, and any lessons learned. It is based on development of expertise and how experts use experience to reason and learn. Case-based learning necessarily places the learner in charge of his or her learning and encourages knowledge generalization (transfer), helping learners to apply lessons learned in more than one context.

The intended function of a case is what ultimately defines its content and form. Jonassen (2006) articulated five different functions that cases may play in learning environments: cases as exemplars (analogies), cases as remindings (case-based reasoning), case study method, cases as problems to solve (problem-based), and student constructed cases. In the six course curricular sequence we have designed, we provide three different kinds of cases. Each course consists of approximately ten learning modules which can contain any or all of these three kinds of cases. Learners approach the modules by studying an *exemplar-type case*, which we term a 'primary scenario.' The primary scenario is a completely worked-out case which describes a particular application of radiation or an example RPT activity. Examples of the former from the Radiation Fundamentals course include the scenarios: "Using radiation to gauge material thickness;" "Applying neutron activation analysis (NAA) in forensics;" and "Producing and sustaining a neutron flux in a research reactor." Examples of the latter from the Radiation Monitoring course include the scenarios: "Conduct a general survey of a radiological work area and establish radiation fields and stay times;" "Ensure that shielding of a given source reduces source strength to background levels;" and "Determine composition of liquid effluent and whether effluent meets requirements for unconditional release." While learners study these worked out cases, they are also exposed to *cases as remindings* in the form of INPO event reports and industry operating experience. Finally, learners are provided with a *case as a problem to solve*, a case that is intended to facilitate knowledge generalization (transfer). We term these cases 'transfer scenarios.' These cases are structurally similar to the primary scenarios (worked-out, exemplar cases), but are presented in a different context and are only partially worked-out or not worked-out at all. For example, in the Radiation Fundamentals course, learners are provided with the primary scenario "Non-destructive testing of piping and pipe welds with iridium-192." After they have studied this case, they are provided with the transfer scenario "Non-destructive testing of thick walled piping with cobalt-60." In this structurally-similar transfer scenario, learners are required to conduct analyses, determine procedures, and perform calculations necessary to solve the contextually different but structurally similar radiation protection problem. We believe that by implementing case-based learning in this way, the knowledge learners acquire will be more memorable (Schank 1993) and will be more readily transferred to different and disparate contexts (see Moreno; Valdez 2007).

Situated learning and cognitive apprenticeships

Proponents of situated learning criticize the mismatch between what is taught in the classroom and the learning needs of the real world (such as in the workplace) evident in many traditional approaches to instruction. A central tenet of the theory of situated learning is that much of what we learn is specific to the situation in which it is learned (Anderson; Reder; Simon 1996). Indeed, success in a classroom context does not necessarily translate to success in the context of the workplace. Situated learning theory focuses heavily on the performance of authentic activities situated within specific contexts as a means for acquiring knowledge. Traditional "school work" is not considered an authentic activity. Rather, authentic activities are ordinary activities that take place within a natural culture and context. Some situated learning perspectives (Brown; Collins; Duguid 1989) maintain that knowledge is a product of the activity, context, and culture in which it is used, whereas others (Cobb; Bowers 1999) adopt the position that knowledge *is* activity situated in a social context. Regardless of the theoretical perspective one chooses to adopt, the crux of this theory rests on the notion that what is learned should not be separated from how it is learned and used. In other words, activity and learning are inseparable (Brown; Collins; Duguid 1989). In sum, situated learning theory maintains that knowledge is acquired through performance of an activity in its natural context, and that learning must be embedded within this contextual activity.

A technological tool to support radiation protection technician training

The RPT curriculum is activity-based (as opposed to topic-based) and couched in a case-based, situated learning approach to instruction with a heavy emphasis on performing authentic activities in realistic contexts. By learning about and performing authentic activities, learners gain relevant experience for when they matriculate into radiation protection technician jobs. However, gaining experience requires some form of support, whether that be on-the-job training, coaching or mentoring, or some sort of simulation. In real-world radiation protection contexts, gaining experience can pose risks for novices and can cause significant expenses (i.e., over-exposures, human performance errors). The online learning environment we have developed for the RPT curriculum attempts to provide a framework for gaining such experience through simulating a number of radiation protection activities in realistic contexts.

Architecture of the online learning environment

We have developed an online learning environment that is an integral part of the RPT curriculum. This technology is tightly integrated into the curriculum. The online learning environment has three major structural components: navigation, a case library, and learning supports (Fig. 1). The navigational scheme enables learners to navigate to relevant cases, and also facilitates accessing answers to questions contained within the system. The case library is comprised of primary and transfer scenarios (cases as exemplars and as problems to solve respectively) as well as operating experience and event reports (cases as remindings). The learning supports in the learning environment consist of embedded narratives, the various ASK systems we have developed, as well as a glossary, search functions, and contextual help. In the following sections we specifically discuss system navigation, the ASK system, and the embedded narratives.

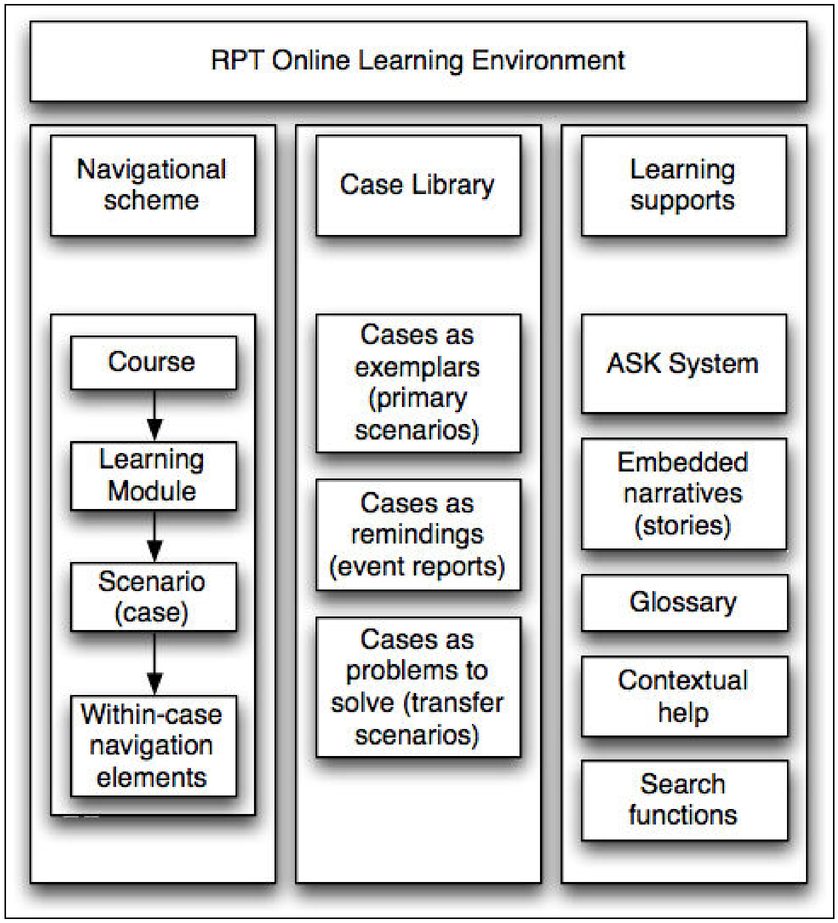

Figure 1.b Components of learning enmvironment

Navigational Scheme

The navigational scheme we have implemented is two-tiered. Learners use a macro navigational structure to navigate to specific cases by first selecting a course, then a course learning module, and then a scenario (case). Once the learner has selected a case, he or she navigates within the case by using the navigational controls within the ASK system and by using back and forward buttons. The navigational controls of the ASK system are comprised of question headings that are hyperlinked to sub-questions, and sub-questions that are hyperlinked to answers in the form of contextualized stories. Learners ask a question within the environment simply by clicking on that question in the ASK system. While working within the ASK system, learners can navigate back and forth between answers they have already viewed by using back and forward navigational buttons, similar to those found in common Web browsers.

ASK System

In order to help students to analyze radiation protection activities and processes, we developed a set of model questions that RPTs should ask whenever they face a new radiation protection situation (an example is provided in the Appendix). Those questions are modeled for students in an online learning environment in the form of an ASK system. An ASK system is a simple application of artificial intelligence that can simulate a conversation with an expert in the form of a multimedia hypertext. Experts are often hard to locate and schedule time with, but a hypertext system can be made available anytime and anywhere via the Internet. Regarding the impact of using ASK systems, although anecdotal reports of implementation of ASK systems in military and business contexts exist (Ferguson; Bareiss; Birnbaum; Osgood 1992; Fitzgerald; Wisdo 1994), we did not find any empirical studies regarding effects of ASK systems on educational outcomes in our literature review. Nonetheless, the ASK system design provides an ideal framework for practical implementation of the learning theories that guided the design and development of the RPT curriculum. ASK systems are well-suited for accessing course scenarios in the form of stories (cases) and for embedding authentic activities (anchoring tasks) within those scenarios.

ASK systems share three common characteristics: 1) categorization of links between texts; 2) implicit domain theories distributed between content and reader; and 3) automatic generation of links between texts for large ASK systems (Fitzgerald; Wisdo 1994). Categorization of links between texts is important in hypermedia environments, as it is easy for users to get lost as they navigate through hyperspace. This is because the framework for linking in hypermedia environments provides users with little to no indication of where they are going, why they are going there, or how they got to be where they are. ASK systems provide users with explicit information about where they are going by using links that are presented as natural language in the form of questions. In addition, users are provided with implicit indicators of location in the hypermedia environment via the context and content of question answers and other contextual cues afforded by the interface.

The ASK system resides in the left-hand area of the Web interface and consists of questions that learners may ask about an authentic work task presented to them in the form of a story-based scenario. Learners ascertain the scope and execution of the activity by selecting from a constrained set of questions provided by the system (see Fig. 2).

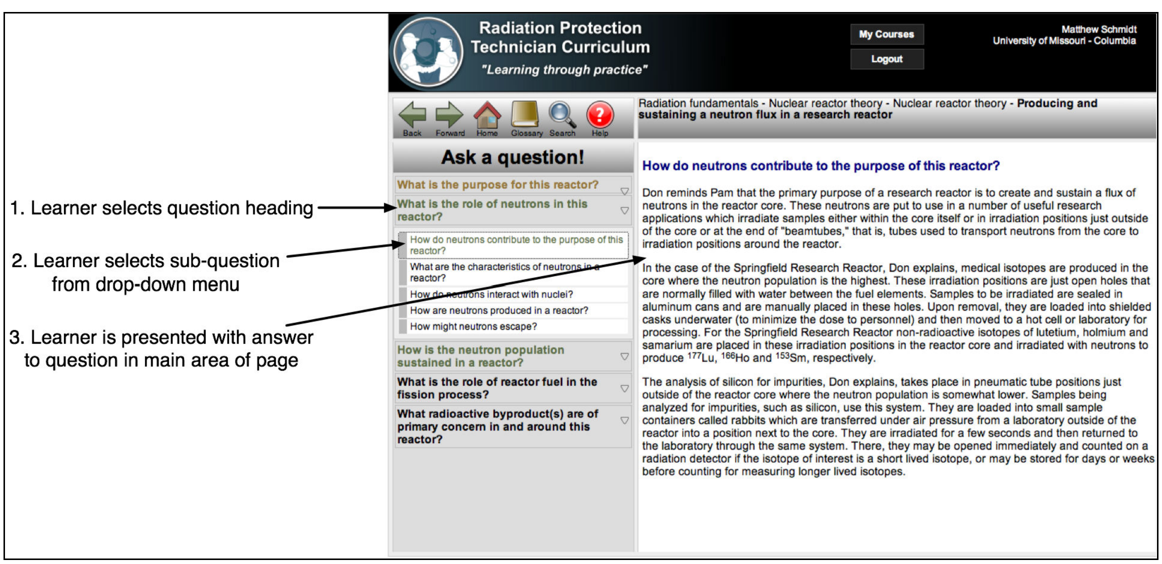

Figure 2. Ask System.

The ASK system enables learners to access expert answers to questions much the same way as they would in the context of completing a real task, that is, by asking questions (Johnson; Birnbaum; Bareiss; Hinrichs 1998). At a basal level, an ASK system attempts to emulate a conversation with an expert (Bareiss; Osgood 1993). This conversation is conducted between learners and the system by means of Aesopic dialogues, that is, dialogues in which the learner selects from a constrained set of questions within the system, and the system responds with pertinent answers couched within stories (Ferguson; Bareiss; Birnbaum; Osgood 1992). The answers that our ASK system presents were gleaned from extensive interviews with expert practitioners. Answers are presented in the form of 30 second to two-minute long video clips, as well as in plain text with associated multimedia components (graphics, diagrams, etc.). The content of these answers along with the ASK system's point-and-click interface are what imbue the system's functionality. In essence, we believe our ASK system facilitates access to expert knowledge, provides for a learner-centric mode of learning, and grounds that learning in the contexts of domain- and task-specific knowledge. We conducted formative evaluation of the online learning environment with students enrolled in the RPT program at one of the community colleges. Data were collected on conceptual problems and preferences, and changes were made according to that evaluation.

Narrative

Within the ASK system, each case (scenario) is presented in a narrative (story) format. The narrative is essentially an organizational scheme expressed in story form (Polkinghorne 1988). Learners are presented with a story when they begin working through a case (scenario) within a given course's ASK system, which we call the "scenario description." For example, for the scenario "Producing and sustaining a neutron flux in a research reactor" in the Radiation Fundamentals course, learners read through a short story about a reporter who works for the *Springfield Gazette* newspaper. The reporter has been assigned the task of reporting on the granting of permits to the nearby nuclear power plant to build a new reactor unit. The reporter decides to learn about nuclear reactors at the local research reactor before going to the power plant to conduct interviews. Learners assume the role of the reporter, and as he or she works through the questions contained in the ASK system, the content of all answers is couched in this narrative context.

We used narrative representations in our design because they are better understood and far better remembered than expository representations. Narrative helps to connect and organize knowledge and skills, personal goals, perception, memory, activities, processes, contexts, events, agents, etc. (Bruner 1990). To be sure, stories are the oldest and most natural form of sense making. Stories are the "means [by] which human beings give meaning to their experience of temporality and personal actions" (Polkinghorne 1988). Humans appear to have an innate ability and predisposition to organize and represent their experiences in the form of stories. Stories help us to learn, to conserve memory, or to alter the past, and allow us to embark on the authentic exploration of experience from a particular perspective.

Intended Outcomes

In the following sections, we provide a description of the intended outcomes of the curriculum: fostering transfer of knowledge and higher-order cognition.

Transfer of knowledge

Knowledge transfer (generalization) is perhaps the most central tenet in education systems today because it reflects a desire for learners to take information that they have learned and apply it to real world contexts (Bransford; Schwartz 1999). Essentially, transfer occurs when knowledge learned in one context affects learning in another context, and it is usually termed as either far or near in nature (Barnett; Ceci 2002). Near transfer usually involves transferring skills to similar contexts or tasks, while far transfer usually involves transferring skills to dissimilar contexts or tasks (Barnett; Ceci 2002). Transfer gains its importance through its ability to test theoretical models of learning and performance, its evaluation of the time and money spent on education, and its ability to exhibit the importance of education in real world contexts (Barnett; Ceci 2002). In our curriculum, such tenets are of primary importance as the goal of this curriculum is to educate and train RPTs to perform duties in real world contexts. Through our practical implementation of case-based and situated learning theories, we believe that learners will be more likely to transfer the knowledge gleaned from the courses to their subsequent duties in the field.

Researchers in case-based learning have suggested that learners who learn via this approach will display more retention of knowledge and will subsequently be more likely to apply this knowledge in different contexts (Schank 1982; Williams 1992; Aamodt; Plaza 1994; Bransford; Schwartz 1999; Kolodner 2002; Didierjean 2003; Gentner; Loewenstein; Thompson 2003; Moreno; Valdez 2007). When cases are used as analogies, the transfer of knowledge from exemplar cases to other contexts has shown to be particularly strong. Indeed, Moreno and Valdez (2007) found that learners who studied an exemplar case were more likely to display immediate transfer than learners in a control group. Moreover, learners who studied a video-based exemplar case were more likely to display delayed transfer than learners who studied a text-based exemplar case.

Higher-order cognition

Most descriptions of higher-order cognition, also termed higher-order thinking, agree that higher-order cognition involves the ability to manage one's own learning process and go beyond any information provided by using critical thinking and evaluative skills in order to solve problems (Lewis; Smith 1993). Simple recall and recognition of facts are located at the lowest level of the cognitive dimension, whereas increasingly more complex and abstract cognitive functions such as the ability to evaluate and create knowledge are located at the highest level. The higher-order thinking skills that the curriculum specifically addresses are prediction, inference, and explanation. Prediction, inference, and explanation are examples of causal reasoning, an essential cognitive skill central to understanding the physical world (Carey 1995; Corrigan; Denton 1996; Brewer; Chinn; Thagard 2000; Schlottmann 2001).

Causal reasoning is required for making predictions, inferences, and providing explanations. However, causal relationships are complex and can be difficult for learners to understand. We have attempted to mediate causal reasoning in the forms of prediction, inference, and explanation in our curriculum using strategies such as anchoring learning content in narrative stories and asking questions. Cases in the form of stories can support learners acquisition of prediction, inference, and explanatory skills (Hernandez-Serrano; Jonassen 2003). Questioning, a fundamental component of reasoning, and answering questions also facilitate causal reasoning (Graesser; Baggett; Williams 1996). In an attempt to draw more attention to learners understanding causal relationships, our curriculum utilizes questions to support learners' predictions, inferences, and explanations. Jonassen and Ionas (In Press) recommend questioning learners about causal relationships using a point-and-query interface for selecting questions relevant to a problem. The ASK system we have developed utilizes a point-and-query interface in which learners select answers to context-oriented questions from a menu modeled after expert question-asking behavior. In addition to the question-driven ASK system, the instructor support materials developed for the curriculum provide instructors with model assessment questions which are designed specifically to facilitate prediction, inference, and explanation. All learning modules are accompanied by a set of these model questions, which instructors can use for quizzes, homework, subject matter for lectures, group activities, etc. In addition, instructors can use these model questions as exemplars for creating derivative or entirely new questions.

Summary

The activity-oriented six-course curriculum component described here provides a framework for acquisition of essential RPT knowledge and skills in a variety of nuclear industry contexts. Because the primary goal of the curriculum is to supply radiation protection technicians to help meet the acute manpower needs of the nuclear industry, the knowledge and skills targeted by the curriculum reflect the real-world skills set of practicing RPTs. The needs and contextual analyses we conducted prior to developing the RPT curriculum indicated that extant models for RPT instruction did not encompass the full breadth and depth of knowledge and skills required of RPTs in the real world, and held the potential to result in workers with knowledge and skills deficits. By focusing on RPT activities as the unit of analysis, we identified a set of tasks that RPTs regularly perform and developed a theoretical and practical framework to support learners' acquisition of the knowledge and skills required to perform those tasks. The curriculum is designed to support transfer of knowledge and development of higher order thinking skills such as prediction, inference, and explanation. Learning theories such as case-based learning, situated cognition, and cognitive apprenticeships support these objectives, and are reflected in our design of curricular materials, including an online, question-driven ASK system that acts as a case library and models expert question asking behavior. By emphasizing real world activities in realistic contexts, we believe the knowledge and skills that learners acquire in this curriculum will be more readily transferable to the workplace. However, as the curriculum is currently in a very early phase of deployment, these beliefs have yet to be supported by any data. At present, an evaluation plan is being implemented and initial formative evaluation data are being collected. The findings from these data will be reported in future publications.

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Appendix: Technician Curriculum Development Initiative Appendix: Courses and course descriptions from the Radiation Protection

RPT 103: Radiation Fundamentals. This course presents an overview of the physics and chemistry of radiation and radioactive materials. This course consists of descriptions of a number of different applications of radiation, their associated radionuclides, context(s) and rationale(s) of use, interactions with matter, shielding and energetics, decay products and their production in reactors or accelerators. Included in the course are appropriate mathematics, such as unit conversions and exponentials.

In this course, learners will develop a fundamental understanding of radioactivity, radioisotopes and radioisotope properties (use, decay mode, emissions, interaction, shielding, half-life), including the systems that produce isotopes (reactors and accelerators). The learners will be able to find and determine pertinent properties of radioisotopes and how these properties affect their usage and control.

RPT 113: Radiation Monitoring. This course presents scenarios in which radiation protection technicians (RPTs) monitor sources of radiation. A focus of this course is on theory and operation of radiation monitors, maintenance and calibration of these systems, proper selection and use of various monitoring systems for evaluation of radioactive hazards, and the interpretation and reporting of such evaluations.

In this course, learners will gain knowledge and skills for radiation detection instrumentation and their use in monitoring radiation and dose. The learners will be able to select appropriate monitoring instrumentation for given radionuclide(s) and/or workplace condition, insure that the instrument is in proper working order and use it to perform material and equipment surveys, workplace surveys, and environmental monitoring.

RPT 223: Radiation Dosimetry. This course presents scenarios in which RPTs monitor internal and external exposure of personnel to ionizing radiation such as when performing surveys, whole body counts and bioassays. The course addresses interpretation of these results and techniques for minimization of personnel dose.

In this course, learners will demonstrate an understanding of radiation dosimetry (internal and external), the effects of radiation, and techniques for the prevention and/or minimization of dose. The learners will be able to select and correctly use appropriate dosimetry devices, use them to predict internal and external doses to personnel, interpret these results and provide guidance on prevention of personnel exposure.

RPT 233: Radioactive Materials Handling. This course presents scenarios in which RPTs are required to provide safe control, movement, use, storage, transportation and disposal of radioactive materials.

In this course, learners will gain knowledge and skills for the safe control of materials using radiation monitoring, encapsulation/containment methods, minimize personnel exposure time, decay, distance (remote handling) and shielding. The learners will be able to inventory material, select mitigation methods, develop handling procedures, and prepare radioactive materials for transportation according to current regulations.

RPT 243: Radiological Safety and Response. This course presents scenarios in which RPTs are responsible for ensuring and maintaining doses ALARA (As Low As Reasonably Achievable) for the safety of individuals, the work environment, and the population, including response to abnormal and emergency radiological conditions.

In this course, learners will develop conceptual understanding and skills for ensuring and maintaining safety in the use of radioactive materials, with an emphasis on implementing ALARA principles. Learners will be able to use the concepts of time, distance and shielding, and protective clothing to minimize dose in a variety of situations (both routine and off-normal) within radiological environments.

RPT 253: Radiation Protection. This course is a capstone course which utilizes a problems-based approach to learning. This course presents radiation protection problems embedded in different radiation contexts, the majority of which are nuclear power reactor-based. Learners are tasked with solving such problems as providing radiological coverage of jobs and high-risk and low-risk activities (e.g. outages), planning for protection from hazardous radiation, monitoring of activities in radioactive zones, and responding to emergencies.

In this course, learners will demonstrate the radiation protection knowledge and skills developed in prior coursework and integrate and apply radiation protection principles through a problems-based approach to learning via real-world applications, primarily focused upon reactor-based systems.

RPT 290: Internship. The learner serves a paid internship of approximately 320 hours with an industry, governmental, or educational institution that uses radioactive materials and requires radioactive protection technicians. The learner is expected to apply learned skills and training to be a productive employee and the employer is expected to place the learner in an environment that will build on the his or her first year of study and enhance his or her knowledge of working with and around radioactive materials.