POTENTIAL FOR ACTIVE ENGAGEMENT IN RADIATION PROTECTION TRAINING

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ABSTRACT

At Louisiana State University and Agricultural & Mechanical College (LSU) in Baton Rouge, Louisiana, USA, thousands of students have benefitted from the incorporation of active engagement strategies in STEM (Science, Technology, Engineering, and Math) disciplines. Students utilizing these opportunities are found to have statistically increased course performances and retention rates. Incorporation of these strategies at other universities in well-designed pre-test and post-test settings also indicated that students showed improvements in scores more than double those using traditional approaches. As LSU Radiation Safety Office conducts numerous trainings for different audiences regularly, we are interested in finding whether these strategies would also be effective if implemented in radiation protection training. Research suggests that as little as 5% of content is retained in lecture based trainings. This is unacceptable when a key component of safety relies on successful training of the individuals themselves. A comprehensive review was performed to summarize several of the utilized active engagement strategies in safety training and how they could be used in radiation protection training. The literature review revealed that several of the issues that lead to poor content retention in radiation protection training are very similar to those regularly studied in pedagogical research. Incorporation of applicable strategies that include problem based learning, andragogic approaches, and learner centered training manuals would likely significantly improve the amount of information that the trainee retains. While statistical testing of long-term training success is very difficult in a real world environment, data suggests that at minimum increased trainee self-efficacy is well reported. With such evidence of improvement, preliminary research has begun to determine whether full incorporation of these strategies could be feasible in this environment. Nonetheless, research suggests that there is not a consensus on the difficulty of implementation. While some argue that, in the long term, active-learning based teaching may take the same or less effort on the instructor. Others identify a large upfront time and effort investment that may not be cost effective. It is likely the case that starting small and slowly implementing these active engagement strategies over a long period of time may be the most prudent method.

1. Introduction

1.1 Background

At Louisiana State University and Agricultural & Mechanical College (LSU), initial radiation protection training (like many other environmental health and safety programs) involves a series of online slide presentations followed by written exams specific to the type of radiation the trainee plans to work with. The online portion of the training is separated into 12 modules (or 12 PowerPoint slide presentations); 6 of which are required of all users and are general radiation safety guidelines, and the other 6 are specific to different types of radiation sources such as radionuclides, x-ray production machines, sealed radioactive sources, and irradiators.

Once a trainee receives a satisfactory score on the written exams, the individual is considered as a radiation worker. After the first year, annual, in-person refresher trainings are required to be delivered by the principal investigator responsible for the trainee. Regular radiation surveillance inspections provide feedback on how successful the refresher trainings are. If a common trend is noticed in worker's weaknesses of understanding, the training and exams may need to be revisited to make sure the information is appropriately communicated. For example, during semi-annual inspections we may find that workers are forgetting to test the battery of a Geiger–Müller meter before use, the online slides are then modified to address this oversight and an additional related test question is added to the exam. Alternatively, the responsible principal investigator may be notified of certain information they need to include in that year's annual training.

This approach was historically chosen, because it maximizes not only the efficiency for accommodating new radiation workers, but also the number of people who can go through the training. It also keeps a benchmark of expectations consistent. There are hundreds of radiation workers in university settings and corresponding trainings must be realistic. However, recent research on classic approaches by lectures prompted the staff in the LSU's Radiation Safety Office (RSO) to reconsider if this was the optimal way to deliver the radiation protection training.

Members of the RSO who have been collaborating with LSU College of Engineering identified that small changes to lectures and review sessions would have large impacts on the percentage of students passing the courses [1]. Incorporation of active learning strategies were credited for these significant improvements. As deeper analysis continued, it was found that these improvements could not be explained by other biases (e.g., self-motivation or good student bias) and appeared to depend only on the active engagement strategies used in the review sessions [2]. Strategies used by LSU included "think-pair-share, group work, minute papers, scribe and orator, and simple techniques such as handing the white board marker to a student" [1]. All of these strategies can be summarized as practices of actively involving the students in the learning process and not simply talking to them.

While the above mentioned research focused on STEM (Science, Technology, Engineering, and Math) curriculum and teaching students, it may be extrapolated to argue that traditional lecture-based models of teaching, or worse so, online slides, are not engaging enough for students nor trainees to benefit from long-term retention of the content. A review of the connection among pedagogy (i.e., the science of teaching students), andragogy (i.e., the science of teaching adults), and safety training is contained herein with possible options for the radiation protection training program at LSU to enhance.

1.2 Pedagogy

Pedagogy, the method and practice of teaching, for many years has been investigating better methods of communicating information to students. The difficulties that may influence a trainee's inability to remember or apply radiation safety practices are numerous according to this field. However, three general principles can summarize well the overarching themes of pedagogy. These are Blooms taxonomy [3], dimensions of learning [4], and Ebbinghaus' forgetting curve [5].

Bloom's taxonomy [3], sometimes referred to as the learning domains, establishes a hierarchy of cognitive understanding and emphasizes that different levels of understanding require different cognitive skills [6]. Understanding of deeper learning could lead to better training of radiation workers. Bloom's taxonomy was modified as psychology research grew. The hierarchy, in order of increasing complexity, is now remembering, understanding, applying, analyzing, evaluating, and creating [7]. Each step in the hierarchy involves deeper understanding of the content. It specifically acknowledges that memorization (remembering) is the weakest level of understanding and long-term comprehension is best obtained by doing something more than just memorization. In 2015, Nancy Adams found that "information professionals who train or instruct others can use Bloom's taxonomy to write learning objectives that describe the skills and abilities that they desire their learners to master and demonstrate. The taxonomy is useful in two important ways. First, use of the taxonomy encourages instructors to think of the learning objectives in behavioral terms to consider what the learner can do as a result of the instruction. Second, considering learning goals in light of Bloom's taxonomy highlights the need for including learning objectives that require higher levels of cognitive skills that lead to deeper learning…" [6]. According to Bloom's taxonomy, radiation protection training should strongly consider not to make memorization-based test questions. Even if a trainee gets the question correct, it does not necessarily prove adequate understanding of the content.

Similar to the learning domains, the dimensions of learning establish that the progression of learning is a process. There are five dimensions in the original model [4]. These dimensions can directly apply to radiation protection training. The first dimension, *attitudes and perceptions*, recognizes that negative opinions towards safety or even the information delivery method can significantly decrease the trainee's ability to learn. The second dimension, *acquire and integrate knowledge*, is a recognition that new information delivery must be guided to first acquire the information (or model), then process the information, and finally internalize or practice the information. A radiation protection training example of this may be to first introduce steps for how to use a radiation survey meter, then show what those steps look like on an actual meter, and finally let the trainees use the meter themselves.

The third dimension is for the learner to *extend and refine the knowledge*. This dimension is where the learner takes the acquired knowledge and refines it by reviewing or comparing it with the reasoning process. In radiation safety, this is likely where the trainee discovers why certain regulations are in place and subsequently can think critically as to if and how the current procedures are good methods of implementing those regulations. The fourth dimension is *using knowledge meaningfully*. In training, radiation workers should use the meters themselves, or practice the calculations that they may be required to do. At a minimum, the workers should be able to describe how they will incorporate radiation safety practices into their jobs.

The final dimension is *habits of mind*. This important final stage is where trainees would look back on the information presented critically and ask themselves, "Do I understand this material appropriately?" While this is very difficult to incorporate in training depending on the audience, it may be most effectively seen in routine inspections of the radiation workers.

The curve of forgetting, another principle in pedagogy, is regularly debated due to its difficulty to accurately quantify the variable; strength of memory [5]. Regardless of the exact logarithmic or power function of this variable, the application remains consistent. As time passes, we forget things quickly. Ebbinghaus believed that this curve was exponential and that there is an obvious loss of information even after 20 minutes. The recommendation to alleviate this loss is regular study periods following the original information. This shift increases the information retained immediately and reduces the amount of information lost long term.

Pedagogy research has found that traditional teaching approaches are significantly improved (by a factor of 2-3 times) by more actively engaging in the communication process [8]. This active engagement (or active learning) can be accomplished in many ways, but it is summarized by using teaching strategies that require participation on the students and include regular feedback to the instructor on if the students are able to capture what is being spoken.

Pedagogy has also found significant variations in the preferred teaching methods that are dependent from student to student [9]. The ways students perceive, receive, process, and apply information may vary drastically depending on the individual. This strongly implies that no training program will be perfect for all trainees, but general approaches may be useful. For example, research inspired by Felder’s learning styles found that 80% of engineering students preferred learning visually (input modality) and 90% of engineering professors preferred learning visually compared to verbally (in this context verbally was described as lecturing or reading and visually is described as charts, pictures, or graphs) [10].

1.3 Andragogy

The split between young adult and adult creates a grey area of training in a university setting. Andragogy specifically studies adult learning compared to pedagogy which generally focuses on children or young adults. While there is significant overlap in these two fields, Malcom Knowles identified several rules in his andragogic model that differs from pedagogy. These rules ought to be considered when designing a training program that may be geared towards adults.

There are 6 rules in the model. The first one is *the need to know*. This rule states that adults must know why they need to learn something before they will learn it [11]. Applied to radiation safety, the assumption here is obvious. However, it is not necessarily regularly communicated. One could consider using phrases such as “It is important to understand these principles to keep your dose as low as reasonably achievable (ALARA)” or “failure to uphold these rules will result in potential fines to the worker, principal investigator, or university.” This will help adults recognize why the information is needed.

The second rule according to Knowles is *the learner self concept*. This rule accounts for an adults need to be treated by others of capable of self direction [11]. It is important that the training is neither to childish nor overly complicated. With adults, some assumptions of responsibility can be made such as the adult is metacognitive and wants to succeed at her/his job. Conversely, over simplification of the content may be too immature and be below the need this rule identifies.

The third and fourth rules are expansions of similar pedagogy themes. The third rule is *the role of the learner’s experience*. This rule conveys students who have experiences already involved in every subject [11]. This rule is even more true with adults as experience will likely be even greater. Similar to the first rule, the fourth one is *readiness to learn.* If an adult can recognize that the training information relates to a realistic life situation, they will be much more likely to be ready to learn [11].

The fifth rule, *orientation to learning*, is where strong differences are obvious between children and adults. Children are typically taught subject-oriented when learning, where adults are normally more life-centered in their learning. This reiterates that adults are more interested in content that applies to their lives when compared to students who learn what they are told to learn [12]. Likewise, the sixth rule, *motivation*, acknowledges that adults are responsive to external motivators such as higher salary, but most motivation is internal pressures such as selfesteem, quality of life, and satisfaction [11]. Students, in general, respond more to external motivators such as grades [12].

1.4 Online Information Delivery

While not a field of science, slides, most often PowerPoint, as a lecture tool have been somewhat studied. Unfortunately there is little information about how slides do by themselves for delivery of information, and most conclusions drawn from research of slides are accompanying lectures. In 2012, Weimer summarized PowerPoint as “not inherently good or bad…it’s all about how we use it.”[13]. This conclusion was based significantly on research published by Hill et al. in the American Sociological Association’s journal. This publication found that the only times PowerPoint slides offered grade improvements were in courses where the professor provided the slides before class. This increase was attributed to preparing the students, not the slides themselves. Most other research concluded that slides offered no measurable grade improvements but may improve grade perception [14]. The authors go on to point out that other literature has found PowerPoint inherent design counters critical thinking and is geared more towards marketing. The authors also argue that students’ perceptions were indeed that PowerPoint helps significantly with paying attention and comprehension.

Although it is good that students’ perceptions improve, there are no obvious benefits between during lecture and without lecture. Online delivery of training information leaves several holes when it pertains to pedagogy. Fortunately, the field of e-learning is growing. Even though at this point research is mostly anecdotal, there are several options and suggestions for using pedagogy and andragogy in online material.

Other researchers have found success in utilizing online videos, but recommend that there are critical decisions that must be made during development [15]. This research was based on 6.9 million video watching sessions in four courses measuring how long students watched the video (without skipping or exiting) and grading post-video assessment questions. Six of this study’s conclusions offer strong aid to future radiation protection training ideas. They are: (1) videos need to be shorter than 6 minutes and planned well, (2) videos with a talking head (smaller video of the instructor speaking) and slides are more engaging, (3) personal feel in videos may be more successful then studio recordings, (4) tablet drawing tutorials are more engaging then PowerPoint slides, (5) classroom style recordings were not as engaging, and (6) fast talking and high enthusiasm is more engaging [15].

2. Considering Change

The goal of our radiation protection training is to equip workers with the knowledge necessary to use radiation safely, obey the ALARA guidelines, and comply with all federal, state, local, and institutional regulations. The better retained the training content is, the more likely it is that safety and regulations will be followed. The initial reasonable question we asked was, “does the radiation protection training need to be modified?” Since there is no measureable indication that the current training is not adequate, arguably the training is meeting expectations. However, based off literature review, there were reasonable suggestions that can be adopted to potentially improve the current radiation protection training.

Scheduling regular, small group, in-person trainings with active learner-centered and hands-on approaches would likely be the most effective method of training. While it may seem to be a desirable option, one must consider the potential constraints such as the number of radiation workers and lack of available time for the instructors. Per regulatory requirements, the radiation workers must successfully complete their training before they are allowed to work with any radiation sources. This may leave significant amount of time between hiring and training where the person is not utilized.

It was also decided that the current method of testing did not need to change. The tests are reviewed with the trainee immediately after the tests on a one-to-one basis. This offers an excellent avenue for active engagement, assures the trainee's understanding of the material, and sets a consistent benchmark of expectations for regulatory purposes. The online portion of the training content appears to be the area that could be improved from the aspects of active engagement and the science of teaching.

2.1 Interactive online modules

Based off of the summation of literature reviews, it was decided that interactive online videos were likely the best replacement for the current PowerPoint slides. Per pedagogy and andragogy recommendations, considerations for what material will be delivered was revisited.

Online videos will continue to use slides, but in video format with a talking head. This will allow for the video to be more engaging and the information to be better retained. The organization of the content would be kept in short (i.e., less than 6 minutes) modules which are relatively consistent with the current approach. The material within each module would follow the dimensions of learning where: (1) a benchmark of understanding or relation to the trainee will be established, (2) only what is considered directly relevant information would be included and the knowledge would be delivered, (3) examples of use will then be covered, and (4) expectations will be clearly reiterated. For example, a module on laboratory surveys may include: (a) introduction to why a laboratory survey is relevant to their work, (b) what a laboratory survey looks like, (c) an example laboratory survey, and (d) what may be looked at by a regulatory inspector. Finally, andragogic rules will be also considered. It will be repeatedly made clear why the information is applicable to the trainees' work and why they need to know it.

Each short video will be followed by multiple-choice, conceptual questions. While this will not be graded, it will prevent access to the next module until the correct answers are selected. This will also help reiterate what the instructor considers the most important message of the video.

3. Conclusions and Discussion

According to these findings, the LSU RSO plans to pilot a test, using a randomly selected group on campus, to measure the effectiveness, cost, and difficultly of implementing these alternative trainings. If successful, it is the intention of the RSO to replace all of the existing online training modules with similar videos.

Perfect modeling between training sessions and normal university classes is unrealistic. There remain obvious differences between these two groups, similar to the differences between pedagogy and andragogy. Students get grades based on their performance on exams and trainees simply pass or fail (and must retake the exam). Conversely, students pay for the courses, and most of the trainees are being paid to work at the university. However, it still seems reasonable that the scientific theories behind students better absorbing course material could be applied to trainings. Likewise, true testing of these changes will possibly be limited to anecdotal experiences as proper statistical setups would not be in the scope of many safety professional's responsibilities or goals.

Despite these differences and ability to easily test for success, the general ideas of pedagogy and andragogy can still relate to radiation protection training. Our ultimate goal is to help keep radiation workers safe. The more trainees actively and attentively engage in training, the more likely they will remember the training content. The better trainees remember and apply the content, the better they will understand the content. The better trainees understand the content, the safer the trainees will be.

4. References

[1] Wilson, C., Steele, A., Waggenspack, W., Wang, W., & Ramsey, L. (June 2015). Engineering Supplemental Instruction: Impact on Sophomore Level Engineering Courses. *2015 ASEE Annual Conference and Exposition Proceedings*. doi:10.18260/p.23983

[2] Wilson, C., Waggenspack, W., Steele, A., & Gegenheimer, J. (2016). The Unsubstantiated Cutoff: Deeper Analysis of Supplemental Instruction Sessions on Engineering Courses. *2016 ASEE Annual Conference & Exposition Proceedings*. doi:10.18260/p.27025

[3] Bloom, B. S. (1956). *Taxonomy of educational objectives: the classification of educational goals*. New York: D. McKay.

[4] Marzano, R. J., & Pickering, D. (2006). *Dimensions of learning: teacher's manual*. Heatherton, Vic.: Hawker Brownlow Education.

[5] Murre, J. M., & Dros, J. (2015). Replication and Analysis of Ebbinghaus' Forgetting Curve. *Plos One,10*(7). doi:10.1371/journal.pone.0120644

[6] Adams, N. E. (2015). Bloom's taxonomy of cognitive learning objectives. *Journal of the Medical Library Association : JMLA,103*(3), 152-153. doi:10.3163/1536-5050.103.3.010

[7] Anderson, L. W., Krathwohl, D. R., & Airasian, P. W. (2001). *A taxonomy for learning, teaching, and assessing a revision of Bloom's taxonomy of educational objectives*. New York: Longman.

[8] Redish, E. F. (2000). Discipline-Based Education and Education Research. *Journal of Applied Developmental Psychology*, 21(1), 85-96. doi:10.1016/s0193-3973(99)00052-0

[9] Felder, R. M., & Silverman, L. K. (1988). Learning styles and teaching styles in engineering education. *Engineering Education*, 78(7), 674–681.

[10] Felder, R. M., & Brent, R. (2005). Understanding Student Differences. *Journal of Engineering Education,94*(1), 57-72. doi:10.1002/j.2168-9830.2005.tb00829.x

[11] Crawford, S. (n.d.). Andragogy (PDF). Retreived April 13, 2017, from http://academic.regis.edu/ed205/knowles.pdf Regis University.

[12] Pappas, C. (2015, November 09). Pedagogy Vs Andragogy In eLearning: Can You Tell The Difference? Retrieved April 13, 2017, from https://elearningindustry.com/pedagogy-vs-andragogy-in-elearning-can-you-tell-the-difference

[13] Weimer, M. (2016, May 23). Does PowerPoint Help or Hinder Student Learning? Retrieved April 13, 2017, from http://www.facultyfocus.com/articles/teaching-professor-blog/does-powerpoint-help-or-hinder-learning/

[14] Hill, A., Arford, T., Lubitow, A., & Smollin, L. M. (2012). "I'm Ambivalent about It". *Teaching Sociology,40*(3), 242-256. doi:10.1177/0092055x12444071

[15] Guo, P. J., Kim, J., & Rubin, R. (2014). How video production affects student engagement. *Proceedings of the first ACM conference on Learning @ scale conference - L@S '14*. doi:10.1145/2556325.2566239.