PRINCIPLES OF ADULT LEARNING: APPLICATION FOR MINE TRAINERS

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ABSTRACT

Safety and health professionals from all sectors of industry recognize that training is a critical element of an effective safety and health program. A major concern in the mining industry is how to train both an aging workforce and the expected influx of new miners and mine managers as older workers retire. Thus, a review of some of the basic principles of adult learning may be helpful to mine trainers. This paper discusses the principles of adult learning based on research in education and psychology. It stresses the importance of taking a systems approach to training, focusing on the relationship between the environment and technology, and understanding how workers interact with both. The authors argue that the principles of adult learning and a systems approach are fundamental to the delivery of effective training in the mining industry. Examples of training programs developed by the Pittsburgh Research Laboratory of the National Institute for Occupational Safety and Health are presented within two broad performance domains: routine and nonroutine skills. Basics of curriculum development are also briefly presented to provide the mine trainer with a template for program development.

INTRODUCTION

Recently, the mining population has undergone numerous changes, including increases in the age of employees, diversity of experience, and increased variety in age, ethnicity, and cultural background. These changes require a different way of thinking about the mining population with respect to training. Instead of following the traditional model of an instructor imparting knowledge to passive learners, training must allow learners to draw on experience, link concepts to real-world situations, and transfer knowledge from one situation to another (Lankard,1995). Adults have their own unique ways in which they learn, and it is important for instructors to design training programs and materials around these ways. Caudron (2000) has noted that trainers frequently do not teach the way adults learn. This thought is reflected in the mining industry, where trainers are usually experienced in specific content areas, but may not be knowledgeable in adult learning or various educational methods. Most mine managers seem to be sold on learning but not necessarily on training. Could this observation—that trainers are content-wise but not well versed in educational principles—be part of the disconnect?

According to the 1999 American Society for Training and Development (ASTD) State of the Industry report (*in* Caudron, 2000), instructor-led classroom training is still the predominant way of teaching adults in the workplace. In fact, this study showed that 70% of all training still consists of an instructor talking about or sometimes demonstrating concepts. But research shows that adults, in general, don't respond well to "lecturers." These researchers note that the most unforgettable learning experiences occur through personal experience, group support (figure 1), or mentoring.

With a renewed and expanded focus on training in the mining industry, as evidenced by formation of the Mine Safety and Health Administration's (MSHA) Educational Field Service, it is appropriate to review basic information on curriculum development and adult learning. Learning by experience is important in that adults learn best by having experiences and reflecting on

Figure 1.—Group learning.

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them. Group learning experiences are also important. In groups, learners can help each other understand the material and learn from each other. In addition, the context of the learning is important, as most adult learners want to know how what they learn will apply in the workplace.

This paper presents basic knowledge of adult learning curriculum development and a model for a systems approach to training with the express goal of providing mine trainers with additional tools to enhance their effectiveness and meet the training challenges of the mining industry today.

DEVELOPING A CURRICULUM

First and foremost, in planning training classes, the following five points need to be considered and may provide a skeleton or checklist for the trainer (figure 2).

1. Clear goals

What is the point of this training? What are the individual capabilities or expected outcomes of the training? It is important to clarify the instructional focus for yourself and for the trainees.

2. Content

What content will support the stated goals? For example, if the goal is "to increase individual safety behavior around power sources at the mine site," what information should be presented to reach that goal?

3. Appropriate delivery mechanism

Is it best to present the material through lectures, demonstrations, videos, or software programs? Should trainees receive the instruction individually, with partners, in teams, or as a group? Teaching methods must address not only the content to be delivered, but different learning styles as well. No approach should be used just because it is the latest method of instruction. The delivery method needs to be carefully evaluated. For example, teaching methods that draw on the knowledge of older workers in class and generate discussions with younger workers may be a very successful way to transfer knowledge, but that notion should be put to the test under given circumstances.

4. Assessment

Assessment is key in planning an educational experience. Assessment should be built into the program. How will you know if your trainees have learned the content? How will you know if the learning goal has been reached? For example, a table-top simulation might have the teaching of critical escape skills as its goal. For these types of skills, a mastery of at least 90% of the exercise content is a reasonable standard (Cole et al.,1984). A lower performance is seen as undesirable because the real-world consequences can be severe. The measure used could be simply the exercise's total score expressed in a percentage of correct performance. Then, if only 20% of the individuals in the class attained performance scores at or above 90% mastery, the trainer would know he or she should offer some remediation.

5. Remediation

Finally, all effective educational programs need a remediation component. If the assessment indicates that the trainee "doesn't get it," a preplanned intervention is called for. This is particularly important when training in critical skills such as putting on a self-contained self-rescuer (SCSR). For instance, the "3+3" training protocol[3] requires a trainee to demonstrate proficiency while being evaluated immediately after having received initial instruction in the task. If an error is committed, it is corrected by the instructor, and the entire process is repeated. This cycle of demonstration—remediation—demonstration continues until the trainee exhibits immediate mastery of the donning process (Vaught and Cole, 1987).

- ❑ **1. Clear goals**
- ❑ **2. Content**
- ❑ **3. Appropriate delivery mechanism**
- ❑ **4. Authentic assessment**
- ❑ **5. Remediation**

Figure 2.—Checklist for developing a curriculum.

ADULT LEARNING

According to Caudron (2000), there are several important concepts adult trainers should practice. She encourages the use of collaborative interaction, an atmosphere where learners and instructors support each other in the process both in and out of formal learning, and the use and encouragement of cooperative communication. She also suggests trainers remember that peoples' feelings are critical in developing relationships in any learning situation.

These concepts fit with adult learning theory. While there is no one theory or one best theory of adult learning, those that recognize that adult learners come to the learning situation from a particular environment and with a personal history seem most appropriate. Adult learning is about "the promotion of active learning grounded in the past experience of the learner and in the application of the knowledge at a personal level" (Puliyel, 1999, p. 513). That application generally takes place in relation to places and things. It is important for a trainer to understand how adults learn, and it is important for him or her to understand the concept of a systems approach in order to plan appropriate and effective training.

[3]The "3+3" training protocol is explained in more detail in the section on "Application of Adult Learning Principles to Nonroutine Skills" in this paper.

KNOWLEDGE

Until recently, theory in adult learning was approached from a psychological perspective, meaning that the focus was on individuals. Newer thinking, as suggested above, takes a broader perspective and includes the environments in which adult learners function as well as the dynamics of group learning (Merriam, 1993).

According to Ference and Vockell (1994), adults respond best to learning that is *active* and *experienced-based.* Adults like interactive learning and learning they can relate to the basis of their own experiences. Thus, examples and illustrations need to be relevant to the trainees. Unlike children, adults are *experts* in their own right in specific areas. This expertise needs to be recognized and may be used to meet the learning goal. Adult learners are *independent,* and this independence should be considered when planning delivery methods and remediation. They are *real-life centered* and desire problems, examples, and descriptions from real life (figure 3).

In addition, adult learners are *task-centered* and *problem-centered*. Being problem-centered, adult trainees are quick to focus on a problem and so are *solution-driven.* Adults may also be seen as *skill-seeking*, as many times they are in training to acquire a new job skill and thus are positively motivated and *self-directing*. Adult learners are both *internally* and *externally motivated*. In other words, sometimes an adult will be motivated by the pleasure and satisfaction of learning something new or by the camaraderie of class interaction. Sometimes an adult will be motivated by the resultant increase in pay or certification at the end of the class.

- Active
- Experienced-based
- Learner as expert
- Independent
- Real-life centered
- Task centered
- Problem centered
- Solution driven
- Skill seeking
- Self-directing
- Motivated

Figure 3.–Some principles of adult learning.

PRACTICE

Practice is important to learning. In addition, *how* the practice is done makes a significant difference. In a recent study, Simon (2001) showed that in the short run, practicing several skills in separate but concentrated blocks led to better performance during practice than did interleaving (integrating one skill after another). However, in the long term, interleaved practice led to better learning than did block practice. This study also found that "People are often poor assessors of what they have learned." In some cases, this is not serious, but in others, such as in some surgical procedures, machinery operations, or putting on an emergency breathing apparatus, the consequences can be serious.

EXAMPLES OF THE APPLICATION OF ADULT LEARNING PRINCIPLES WITHIN A SYSTEMS CONTEXT

It is important for mine trainers to apply learning principles within a systems context (figure 4). In other words, the subject matter and approach need to be put within a broad, interrelated context for miners, so both technical issues and social and human behavior and their relationships can be considered. The term used for this type of approach is "sociotechnical systems" research. This approach was pioneered in British coal mines during the 1950's and recognizes that workers and technology interact within a physical and organizational environment. It is understood that change in one component of a system may have both intended and unintended consequences in other components. In mining, work conditions are dynamic, technology is being introduced at an ever-increasing rate, and the workforce, in a shrinking job market, is aging. Because interventions in this context must be multidimensional to be effective, researchers at the Pittsburgh Research Laboratory (PRL) have taken an interdisciplinary systems approach to worker safety and health training. The authors suggest that mine trainers understand and incorporate this approach into their teaching of adult learners.

Potentially hazardous situations that confront miners in their workplaces can be characterized as routine or nonroutine in nature. Elements that contribute to injury in either situation may involve the equipment employed, those procedures used to perform particular tasks, and the behaviors of individuals or groups. Most PRL research on broad problem topics, therefore, has tended to take all three of these elements into consideration. In teaching safety and health, trainers should include all dimensions.

APPLICATION OF ADULT LEARNING PRINCIPLES TO ROUTINE SKILLS

In mining, much human factors and training research has focused upon the reduction of death and injury from falls of roof during routine tasks associated with roof control. A contributor to roof fall fatalities is workers' relative inability to recognize hazards. Unfortunately, methods for teaching mine hazard recognition in the classroom have not changed much over the years. The format for such training usually consists of having workers view slides of hazards or participate in discussions of conditions in their particular workplace. These training approaches assume that informing workers of "problems" will have some impact at a later time when a miner happens to encounter similar hazards on the job. Questions relating as to whether learning will be transferred successfully from a classroom to the workplace are rarely addressed.

The need for improved methods of teaching miners to recognize hazards has been addressed by PRL researchers using an innovative

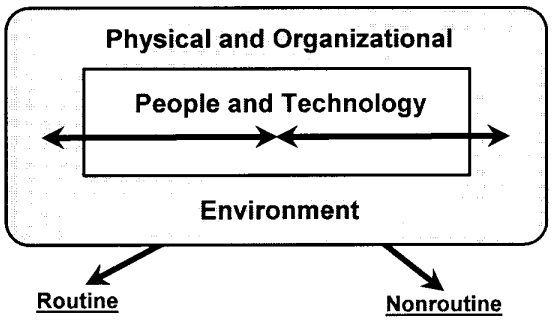

Figure 4.–A systems approach.

form of instruction. This instruction combines the known advantages of table-top simulations with three-dimensional (3-D) slides. Adding 3-D slides to a simulation forms a truly unique training instrument. It figuratively "places" miners in a problem-solving situation where surroundings can be visualized realistically using high-fidelity, 3-D pictures. This approach targets key principles of adult learning in which the learning should be active, experience-based, real-life centered, task-and-problem centered, and solution-driven.

Although these training materials were immediately appealing, little was known about whether they would lead to any improvement in hazard-recognition skills. Nor was it known whether such learning would transfer to the workplace. Thus, the researchers posed the following question: Can training that uses a latent image/3-D slide exercise improve a miner's ability to recognize roof and rib hazards? To answer this question, a real-world experiment was conducted with a small sample (Barrett and Kowalski, 1995).

Six coal miners with similar job classifications and mining experience participated in the first experiment. The miners were assigned randomly to either an experimental group or a control group. The experimental group was trained with a latent image/3-D slide simulation in a classroom at the host mine's training center and took approximately 30 minutes to complete. Each miner worked individually through his problem booklet and responded to the questions. At certain points, exercise directions had the worker view a designated 3-D slide that accompanied a particular question. There were no discussions during the training session, and each miner worked at his own pace.

To investigate the effectiveness of this training, a hazard recognition task was set up in the mine. Twelve areas that contained roof and rib hazards similar to those found in the exercise were identified. These areas were part of a mile-long route traversing two of the mine's major entries. Each area was marked by spray-painting a letter (A through L) on the ribs of the entry. No artificial hazards were prepared at any area; only ones that existed naturally were recorded. These then became keys for the recognition task.

Hazard recognition performance was assessed as subjects from both groups walked through the mine and attempted to identify hazards in each marked area. Each miner was given a pencil and clipboard with 12 sheets of paper labeled A through L. The workers were instructed to walk as a group along the designated route and stop at each labeled station. They were given 1 minute at each stop to identify any roof or rib hazard they recognized.

Subjects wrote their observations on the sheets provided. These written responses were done individually. At no time were group members permitted to talk to each other or discuss the task. Researchers provided no feedback at any time during the entire experiment. The control group, of course, did not receive training prior to the walk-through.

There were 20 points possible for the underground hazard recognition task. Table 1 shows the individual subject scores given as both the number of correct answers and a corresponding correct percentage. The table also shows means and standard deviations for both the control and experimental groups. Note that all experimental subjects who had training prior to the walk-through scored higher than the control group. Given the small sample size, a Fisher Randomization *t* Test was applied to the data. This test confirmed with 95% confidence the hypothesis that the mean score of the experimental group was significantly greater than the mean score of the control group.

Significantly, since human factors and training research and interventions began, **the number and rate of fatal roof fall accidents (especially in small mines) has declined dramatically.** In 1989, 17 deaths were attributable to roof falls, while in 1990, there were 21. In 1994 and 1995, on the other hand, there were five and six roof fall fatalities, respectively.

APPLICATION OF ADULT LEARNING PRINCIPLES TO NONROUTINE SKILLS

Another broad problem topic that has occupied human factors researchers in the past few years concerns miners' emergency breathing equipment. Of particular interest has been the self-contained, self-rescuer (SCSR), a 1-hour, oxygen-generating apparatus. Investigations of the Wilberg disaster and other major mine fires strongly suggested that workers had difficulty putting on their SCSR's in emergency situations, making their escape problematic. Subsequently, human factors researchers participated in performance studies that showed the need for hands-on training with the equipment.

In the course of the research, personnel developed a simplified, standardized procedure, known as the "3+3" method, for putting on SCSR's. This method is based on the principles of adult learning (hands-on, task-centered, and skill-seeking). It lumps all the discrete tasks involved in putting on a SCSR into a logical sequence of three steps that must be completed to isolate a worker's lungs and three additional steps that prepare a worker for evacuating the workplace. The 3+3 method has been adopted almost universally by the coal industry and endorsed by CSE Corp. and Mine Safety Appliances as the approved procedure for donning the companies' models of person-wearable SCSR's.

Table 1.—Performance scores on underground hazard recognition task.

Group, subject	Individual scores		Group scores			
	No.	%	Mean no.	Stand. deviation	Mean %	Stand. deviation
Controls:			10.7	2.5	53.3	12.6
1	11	55				
2	13	65				
3	8	40				
Experimental:			16.3	1.5	81.7	7.6
1	18	90				
2	16	80				
3	15	75				

A TRAINING PROGRAM USING THE PRINCIPLES OF ADULT LEARNING TO ENCOURAGE ADHERENCE

A persistent problem in the coal industry has been nagging doubts about the reliability of SCSR's. One dimension of the reliability issue is the concern that workers do not adhere to manufacturers' recommended inspection and care procedures. To encourage these procedures, researchers developed a training package to teach miners how to conduct routine inspections of their SCSR's, to care for them properly between inspections, and to reinforce the relationship between inspection and care and performance of the apparatus when it must be used.

The package was designed so that, after completing either the video session or the CBT module, the trainee would be able to—

1. Conduct the daily required inspection according to the provided checklist.
2. Conduct the required 90-day inspection according to the manufacturer's recommended procedures.
3. Always properly care for a SCSR.
4. Determine when a SCSR should be removed from service.
5. Know the criteria that require a SCSR to be removed from service.

The training modules contained in this package can be used together or separately as appropriate for any particular audience. The accompanying instructor's guide explains each module and lists related materials. In total, the package includes—

- An Instructor's Guide that gives an overview of the training package and includes an inspection checklist.
- A 5-minute video that introduces care and maintenance.
- A computer-based training CD that covers inspection and care for individual trainees or groups.
- A screen saver to remind users of 3+3 donning procedures.
- Stickers designed to communicate the lifesaving function of SCSR's.

The experience-based, task-centered, SCSR training is an example of the effective use of adult learning principles. This work has been used to support the promulgation of a federal regulation requiring hands-on SCSR training for all people entering an underground coal mine. The overall success of training work on this topic is reflected, in part, by the documented accounts of 3+3-trained workers who have used SCSR's to escape underground mine fires.

CONCLUSION

A grasp of the relationships among the environment, technology, and workers and how these three interact is fundamental to the delivery of effective training. A better understanding of adult learning and how it can be applied within the two broad performance domains of routine and nonroutine is then more probable.

NIOSH research in education and training seeks to offer a continuous array of data leading to economically justified training interventions based on adult learning principles and incorporating a systems approach. These data may be used to define realistic goals, methods, and procedures for successive improvements in safety, mining systems, work crew proficiency, and improved miner training. Such justification will serve to institutionalize increased investments in the workforce and support training in the mining industry.

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