Problem-Based Learning

An adult-education-oriented training approach for SH&E practitioners

By Jim Ramsay and Elbert Sorrell

THE EDUCATIONAL PREPARATION of undergraduate safety students has concerned safety educators for many years. A major debate involves safety program content as well as student outcomes/competencies. These concerns are expressed by Brauer (2005), Freeman and Field (1999) and Sorrell (2003), as well as in documents published by ABET Inc. (2006)—"Program Criteria for Safety and Similarly Named Applied Science Programs"—and ASSE's Educational Standards Committee (2006).

While there is a rich literature that convincingly argues the many sides of this issue, little to no research has addressed the process of safety program curriculum delivery. Currently, definitive evidence cannot be provided allowing one to generalize about curriculum delivery methods used by safety educators; however, one can postulate that the process used to educate safety students is consistent with traditional teaching strategies (e.g., lecture methods) used throughout the U.S. educational system.

The traditional lecture is one of the oldest and predominantly used teaching methods in U.S. colleges and universities (McKeachie, 1994). This format in higher education often represents an exercise in one-way communication that places students in a passive rather than an active role—and that ultimately minimizes the learner's ability to develop higher-order skills such as analysis, evaluation and synthesis of ideas and concepts. Butler (1992), Beers and Bowden (2005) and McKeachie (1994) have shown that the "pure" lecture method is not the most effective teaching strategy to stimulate thought and enhance problem-solving skills.

At the same time, an abundance of literature challenges professionals who train adults to consider moving beyond the lecture method to active learning models that require adult learners to take greater responsibility in their own learning (Butler, 1992). [Note: In this article, *students* and *learners* can refer to either undergraduate or graduate students in traditional higher-education settings since most are over 18 and, thus, adults. However, at the worksite, employees who receive education and training from an SH&E practitioner also are considered adult learners of SH&E training and education programs.]

In general, professionals who train adults, including SH&E practitioners, might agree that an important goal of training and education is to develop in their "students" a desire for self-reliance and effective problem-solving (critical thinking) skills. Therefore, SH&E practitioners and educators alike should consider minimizing the use of pure lecture methods to train employees or students, and instead begin to incorporate active teaching strategies that better prepare employees/students for the complex and dynamic challenges they will encounter in the workplace.

Problem-Based Learning: A Background

The primary purpose of this article is to explore the potential opportunities associated with problem-based learning (PBL), an active adult-learning strategy. PBL was developed as an alternative approach to the education of physicians first implemented at McMaster School of Medicine in 1969. Interestingly, PBL emerged to confront a disturbing reality—that it was possible for medical students to memorize extensively without any sufficient change in their ability to use the information to diagnose diseases. The PBL curriculum delivery model was developed to actively engage medical students in the subject matter and to help develop effective critical-thinking, communication and social skills (McMaster University).

In PBL, learners collaborate to pursue solutions and knowledge they do not currently possess and to study issues related to a problem and determine viable solutions. In this way, PBL is a holistic approach to com-

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plex higher education. It facilitates student achievement by supporting a structured process of using what one knows, systematically obtaining new knowledge and skills once gaps have been identified, collectively applying new and old knowledge and skills, and finally reflecting. Thus, it has become a teaching/learning method and a pedagogical philosophy.

What Is PBL?

PBL is a learner-centered instructional method that enhances one's ability to analyze, synthesize and evaluate problems. It can be described as a teaching strategy in which learners confront contextualized, ill-structured problems and strive for meaningful solutions (Rehm, 1998). It is an instructional method that uses real problems as the primary pathway of learning. The problems used in PBL activities are complex and rooted in real-world situations. They are current and reflect a typical problem encountered in the work environment specific to a particular discipline (PBLI).

As a teaching and training methodology, PBL directly addresses a primary goal of education—to develop learners who are effective problem solvers. The PBL curriculum delivery model recognizes the need to help learners become effective problem solvers and to help them acquire the skills and knowledge associated with a particular profession. Ideally, the process culminates with learners possessing skills and abilities that adequately prepare them for professional occupations where critical thinking, and individual and group work are expected, and complex problem-solving skills are essential for success.

The PBL Learning Process

When engaged in the PBL process, learners are presented with a real-life scenario. They attempt to solve multifaceted and complex problems with information they already know. Then, they determine what else needs to be learned—that is, what they do not know or know how to do. They then engage in self-directed study, researching information needed to effectively address the problem and offer alternative solutions.

After completing the work on the identified problem, learners assess themselves and each other to develop self-assessment and constructive assessment of peers (PBLI). As a consequence, PBL integrates and develops all three domains of learning as described by Bloom (1956), including the cognitive (mental and intellectual skills), affective (feelings and attitudes) and the psychomotor (motor or physical skills).

As a teaching and training methodology, PBL espouses learner-centered education as its primary goal. This process produces students who can define problems, devise alternative hypotheses and develop reasonable solutions to the issues at hand. Ultimately, PBL attempts to produce students who can:

•address complex problems with initiative and enthusiasm;

•solve problems effectively, employing self-directed learning skills when needed;

•continuously assess and acquire knowledge;

•collaborate effectively as a group member.

The Instructor's Role

In PBL, the instructor or trainer functions as facilitator rather than a content expert (although s/he may

be). Indeed, taking the role of facilitator can explicitly reinforce to the student the need for and fun in lifelong learning. Remember, PBL is a process and the instructor's/trainer's role as a facilitator is critical.

The instructor/trainer has three main roles in PBL.

1) S/he helps to develop the questions learners ask about the problem being investigated.

2) S/he helps learners locate and understand appropriate references and resources. In this way, learners clearly identify professionally appropriate resources of their field and can begin to apply them to the problem at hand.

3) S/he helps to create the "final product" or the proposed solution.

Steps of the PBL Process

The PBL process generally involves seven steps.

Step 1: The Case or Problem Statement

The facilitator introduces the issues in order to establish a personal connection to the problem(s) for the learners. This may take the form of a guest speaker, a video, a newspaper story, a photograph or a written case study. This step gives students the background information they need to understand the significance and context of the problem and results in the ill-structured problem statement.

Step 2: The Questions

The facilitator leads discussion with the class to determine the answers to the following questions (teachers may wish to have students work in groups first to answer these questions before leading a large group discussion):

•What do we know (facts of the case)?

•What do we need to know (other facts missing at this point)?

•What do we need to learn more about (the underlying science or social concepts that need more research, elaboration or definition)?

Step 3: Action Plan

Groups of three to five student investigators then make plans for how they will find the information needed. Included in this plan is the effort to develop a list of reliable resources that may advance the investigations. These resources may be published books or articles, community members or Internet sources.

Step 4: Investigation

The groups of student or employee investigators execute their action plans. Facilitators also may choose to have learners engage in a series of activities that provide elaboration or information about the underlying concepts identified during the questions phase. This step is sometimes referred to metacognition—or simply "thinking about how one thinks."

Step 5: Revisiting the Case: Evaluation

Once the independent work is completed, the groups reassemble to report on their work and to revisit the questions. Further investigations will likely be necessary.

Step 6: Final Product or Performance

Each case concludes with a product or performance by the groups or subsets of the groups. Facilitators should provide the investigative teams with possible options of products or performances. These may include plans for further action.

Step 7: Final Evaluation & Feedback

The student investigators evaluate their own performance, their team's performance and the quality of the problem itself. At this point, it is helpful to have the learners articulate what went well and what did not go well during the solution process; this helps to improve how the process initiates and progresses next time.

The question remains: Would PBL be a helpful teaching/training methodology for SH&E practitioners at a worksite? The answer lies somewhat in the nature of SH&E education and training at the site.

PBL & SH&E Education/Training

Whether at the worksite or in the university classroom, or whether the goal is education or training of adults at the worksite, the SH&E profession is characterized by complexity and change. From multiple and competing regulatory realities to adult education and economic analysis; from understanding the near-hits inherent in one's workplace to fatality investigations; from working with unions to top management, SH&E practitioners regularly face complex issues that may not have any obvious solution.

How best to structure the educational preparation of SH&E or risk control students has been a long-term

challenge for educators in this field of study. Academics who teach SH&E and related content have had a long-standing, ongoing discussion regarding recommended student outcomes/competencies.

Some educators may feel that the primary thrust of academic SH&E programs should be technical concerns. Primarily to ensure content integrity, various accreditation organizations and systems, such as ABET (2006) and certification bodies such as the Board of Certified Safety Professionals (BCSP, "What Is a Safety Professional?") have concurred with this position. [Note: BCSP (2006) has reorganized the CSP exam to include four domains of professional responsibilities, one of which is ethics and another is SH&E management. So, while BCSP values engineering and other technical aspects of the profession, it has acknowledged nontechnical components as well. See www.bcsp.org/bcsp/media/exam_guide.pdf.]

Others will argue that an academic safety curriculum should be grounded in management, and still others suggest that safety curriculum should have a balance of managerial and technical content. Clearly, what has influenced this debate is the critical role that SH&E practitioners find themselves in at the worksite—namely, they often train and educate both blue-collar and white-collar working professionals (e.g., physicians, nurses, skill trades and laborers). What is conventionally understood is that the SH&E curriculum can be characterized as broad in scope, as well as having both technical and social science underpinnings, just as it is at the worksite.

The PBL curriculum delivery process complements the goals and challenges of SH&E practitioners who train and educate adults in the workplace. The interdisciplinary/multifaceted nature of SH&E content and the SH&E profession lend themselves well to the PBL teaching model. As such, PBL encourages a more meaningful engagement by adult learners (employees) in problems representative of the scope, complexity and difficulty of real-world SH&E issues they are likely to encounter in the workplace. In this way, PBL helps achieve an important goal of SH&E training and education—the development of employees who are effective, independent problem solvers and lifelong learners. To better illustrate how PBL may be used by SH&E practitioners, two examples are presented.

Application of PBL in the Healthcare Industry

To see how healthcare safety might incorporate PBL tenets, consider the nature of healthcare safety. Healthcare is a complicated, dynamic industry of varied exposures, such as bloodborne pathogens and other biological hazards; exposure to various chemicals and/or drugs, domestic terrorism, waste anesthetic gas, latex and ergonomic exposures (Ramsay, Denny, Szirotnak et al., 2006). For example, consider the following characteristics of hospital hazards:

1) The target audience for SH&E training/education is often highly educated and professionally accomplished (e.g., doctors, researchers, nurses) and, as such, presents specific challenges to the SH&E practitioner.

2) The safety or health hazard can be a complex exposure with no readily available engineering control (e.g., patient transfer, patient violence, gluteraldehyde exposure).

3) The consequences of employee safety and health exposures often directly impact the safety and health of third parties, such as patients.

4) It is not uncommon for a healthcare hazard to include SH&E components (e.g., radioactive waste from chemotherapeutic agents).

Education and training are critical to addressing these issues, which means occupational safety and health educators/trainers play a pivotal role in success. Consider how a PBL approach to education/training might work for white-collar professionals and blue-collar laborers at a healthcare facility.

Healthcare safety issues lend themselves well to a PBL approach because they:

•are related to real-world applications;

•require substantial professional judgment on the part of the SH&E practitioner;

•may lend themselves to multiple solutions that may be controversial in nature;

•lend themselves to higher-order thinking according Bloom's (1956) taxonomy including: analysis (simplifying material into its constituents in order to see interrelationships); synthesis (producing new material from existing component parts); and evaluation (making judgments based on preset criteria).

Step 1: The Case or Problem

Every day, nurses are exposed to many hazards, including ergonomic exposures while moving patients, chemical hazards, occupational stress, workplace violence (especially in the emergency department), exposure to bloodborne pathogens, bioexposures and radiation exposures. While most nurses receive some occupational safety and health training in nursing school and most hospitals are concerned about nursing safety, it is unclear whether and to what degree nurses can identify and control the many hazards encountered in their professional work environment. So, as a hospital SH&E practitioner, you know the financial consequences that result from uncontrolled, yet identifiable nursing hazards. How might you act to reduce costs associated with nursing-related healthcare hazards?

Step 2: The Questions

At this point, organize the students (nurses in this example) into working groups and help them identify what they know, what they do not know and what they need to learn. For example:

•What level of occupational safety and health training do nurses receive in school and on the job?

•What are the accident and illness statistics for nurses over the past 5 years?

•What degree of cost savings is management seeking?

•Are there any union or organizational cultural issues?

•What do current job descriptions include? Do they include safety language?

•What is going on in peer institutions? Has benchmarking been done?

•What engineering controls exist? Are they applied routinely? If not, why?

•Are PPE or administrative controls in place?

•What is the nature of the relationship between working conditions, job satisfaction levels, turnover rates and the level of work hazards?

•Are there some exposures that cannot be addressed?

Step 3: Action Plan

Practicing nurses can now determine how best to locate appropriate resources for things they do not know. Do not allow the students to proceed randomly in this step. The SH&E trainer should guide them systematically. This will help learners better see how a logical action plan is more efficient than a poorly thought-out action plan.

Also, given the information available on the Internet, it is helpful to explain the difference between responsible and appropriate resources and less-reputable sources. This is also a good time to help learners improve organizational and note-taking skills.

Step 4: Investigation

In the investigation step, the learners must implement the action plans devised in step 3. Again, remember that as the SH&E practitioner, you are training highly competent and well-educated adults; therefore, facilitation of a logical, efficient approach is a teaching moment. Precise identification of who is responsible for what and by when is helpful. A Gantt chart or similar tool may be helpful.

Step 5: Revisiting the Questions

Step 5 is the recursive component of the process. At this juncture, the learners should consider what they know, what they still do not know and what they may need to do to answer the remaining questions. They may need to further investigate questions or unknowns, gather more information or do more research before they are able to draw conclusions. The SH&E practitioner should remind the nurses at this point of the concepts of data reliability and validity.

Step 6: Final Product/Performance

Step 6 culminates in a final product such as a report or presentation or both. This is an opportunity to help the learners improve their professional writing and verbal presentation skills since most professional projects should conclude with both a written proposal and an oral presentation. For some employees (perhaps blue-collar employees), the notion of a final presentation of their findings may not be relevant.

Step 7: Final Evaluation

At this stage, the SH&E trainer can guide the students through a review of the process, including an evaluation of the problem statement, the strengths and weaknesses of the proposed final product, what went well and what did not go well, and how/what subsequent improvements are indicated.

PBL to Improve Hazard Communication

SH&E practitioners also can apply the PBL principles to address the education and training requirements associated with compliance programs. The following example applies the PBL process to OSHA's Hazard Communication standard (HCS).

Step 1: The Case or Problem

Chemical exposures are a leading hazard at many sites. Despite training in safe procedures, familiarity with chemicals often leads to careless handling practices. Consider the exposures related to handling chlorinated solvents in a manufacturing setting. Such solvents can be potent hepatotoxins, but they must be used almost daily as degreasers of equipment or tools.

Step 2: The Questions

At this point, the SH&E practitioner can gather maintenance personnel as well as those in skilled trades (e.g., pipefitters, millwrights, electricians) and have them develop a list of what they know, what they may not know and what they might need to do to learn how to better incorporate safer chemical handling and disposal techniques.

For example:

•What injuries and illnesses have been reported by these employee groups over the past 5 years?

•What degree of cost savings is management seeking?

•Are there union or organizational cultural issues of concern?

•What do employees know about the toxicity of chlorinated solvents?

•What is included in current job descriptions and do they include safety language and hazard mitigation strategies? That is, have job safety analyses been performed and have identified hazards been incorporated into the job descriptions?

•What are competing organizations doing about these exposures? Has the firm conducted benchmarking on these exposures?

•What engineering controls exist? Are they applied routinely? If not, why not?

•Are PPE or administrative controls in place?

•What is the nature of the relationship between the prevailing working conditions, job satisfaction levels and turnover rates?

•Are there some exposures that cannot be addressed?

•Is there management pressure to work unsafely? Do supervisors push productivity more than safe work practices?

Step 3: Action Plan

Begin with a test to examine employees' knowledge of the physiological and environmental concerns associated with chlorinated solvents as well as the various chemical properties that make them efficient degreasers. Discuss and analyze the questions and answers.

Next, guide the employees' efforts to find answers to these questions. Many blue-collar workers have

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not had sufficient educational experience and may not have ever been in this kind of situation. The trainer's job is to ensure that the employees embrace the questions/problems as their own and are motivated to find solutions. This is a good time to introduce the concept and process of job safety analysis, which, if performed appropriately, involves both workers and supervisors in the direct identification of hazards associated with each job task and with appropriate controls.

Step 4: Investigation

In the investigation step, the SH&E practitioner can test-drive the solutions developed in step 3. For example, on the shop floor, contaminate tools and equipment just as might occur during a normal workday. Proceed to degrease both the tools and equipment as necessary, pointing out mistakes made in the past, including points where it may be more convenient to violate safety practices or take shortcuts. Walk employees through the entire process, including the handling and disposal of used cleaning solvents, PPE use and any log entries that may be required.

Step 5: Revisiting the Questions

At this point, take a step back and engage the employees. Ask their opinion of the risks of chlorinated solvents, OSHA's training and handling requirements, the efficiencies of their proposed solutions as well as the weaknesses—those points in the process where shortcuts would be tempting—and how near-hits might be reported for training, not punitive, purposes. Review any questions and prepare the employees for the final training and education requirement of the HCS program.

Step 6: Final Product/Performance

In most organizational settings, the final product step may not be relevant to blue-collar workers.

Step 7: Final Evaluation

The last step involves a final review of the training and exercise. This is a good time to give employees an exam that would indicate their proficiency as well as satisfy the HCS reporting, training and education requirements. Upon completion, the employees should be more engaged and knowledgeable of their own safety and better equipped to make solid decisions independently.

Thanks to the PBL process, the practitioner also will be able to demonstrate an education and training program that is in compliance with the regulations. In addition, the stage has been set for the SH&E practitioner to more regularly dialogue with workers and learn about near-hits that can be corrected using a subsequent PBL session.

Conclusion

Problem-based learning is a teaching philosophy and methodology that can be use by SH&E trainers and educators. By applying this methodology with adult learners, trainers/educators can help employees and students develop higher-order decision-making skills and competence.

The PBL process forces SH&E instructors to take on compelling and dynamic challenges in education and training, and allows learners (students, employees) to observe and interact with the instructor in a more intimate, comfortable fashion than is possible with traditional lectures. PBL also requires a greater, deeper level of learner involvement. Ultimately, PBL results in greater learning and more participation while providing learners with the ability to see their instructors as mentors and guides, not simply the "sage on the stage." ∎

References

ABET Inc. (2006). ABET accreditation and procedure manual. New York: Author. Retrieved Dec. 19, 2006, from http://www .abet.org/Linked%20Documents-UPDATE/Criteria%20and%20 PP/A004%2006-07%20Accreditation%20Policy%20and%20Proce dure%20Manual%201-4-06.pdf.

ASSE. Safety curriculum guidelines. Des Plaines, IL: Author, Educational Standards Committee. Retrieved July 16, 2007, from http://www.asse.org/professionalaffairs/govtaffairs/ngposi18 .php.

Beers, G. & Bowden, S. (2005). The effect of teaching methods on long-term knowledge retention. *Journal of Nursing Education, 44*(11), 511-514.

Bloom, B.S. (1956). *Taxonomy of educational objectives. Handbook I: The cognitive domain.* New York: David McKay Co. Inc.

Board of Certified Safety Professionals (BCSP). What is a safety professional? Savoy, IL: Author. Retrieved March 10, 2006, from http://www.bcsp.org/bcsp/index.php?option=content& task=section&id=8&Itemid=34.

BCSP. (2006, Aug.). *Certified safety professional examination guide.* Savoy, IL: Retrieved March 10, 2006, from http://www .bcsp.org/bcsp/media/exam_guide.pdf.

Brauer, R. (2005). Evaluating a safety degree curriculum using job analysis for professional safety practice. *Journal of SH&E Research, 2*(2).

Butler, J.A. (1992). Use of teaching methods within the lecture format. *Medical Teacher, 14*(1), 11.

Environmental Educational Outreach Program. AQCP problem-based learning process. Flagstaff, AZ: Author, Air Quality Curriculum Project, University of Northern Arizona. Retrieved March 10, 2006, from http://www4.nau.edu/eeop/aqcp/pbl _process.asp.

Freeman, S. & Field, D. (1999). Benefits of cross-functional safety curriculum. *Journal of Industrial Technology, 15*(4), 2-7.

McKeachie, W. (1994). *Teaching tips: A guidebook for the beginning college teacher* (9th ed.). Lexington, MA: D.C. Heath.

McMaster University. Problem-based learning: History and overview. Hamilton, Ontario: Author, School of Nursing. Retrieved March 3, 2006, from http://www.fhs.mcmaster.ca/pbl nursing/HistoryOverview.htm.

Problem-Based Learning Initiative (PBLI). Problem-based learning. Carbondale, IL: Author, Southern Illinois University. Retrieved March 7, 2006, from http://www.pbli.org/pbl/pbl.htm.

Ramsay, J., Denny, F., Szirotnyak, K., et al. (2006). Identifying hazards in nursing: A pilot demonstration among VA emergency department nurses. *Journal of SH&E Research, 37*(1).

Rhem, J. (1998, Dec.). Problem-based learning: An introduction. *National Teaching and Learning Forum, 8*(1). Retrieved March 7, 2006, from http://www.ntlf.com/html/pi/9812/pb1_1.htm.

Sorrell, E. (2003). Schools of thought. *Safety + Health, 167*(5), 37-38.