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Problem-Based Learning: A Novel Approach to Teaching Safety, Health and Environmental Courses

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Introduction

The educational preparation of safety pre-professionals has concerned for safety educators for many years. A major concern relates to the debate surrounding safety program content as well as student outcomes/competencies. While there is a rich literature that convincingly argues the many sides of this issue, there is little to no research related to the process of safety program curriculum delivery. At the present time, 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 (lecture methods) used throughout the American educational system.

The traditional lecture is one of the oldest and predominantly used teaching methods in American colleges and universities (2). The traditional lecture format in higher education often represents an exercise in one way communication that places students in a passive rather than an active role and which ultimately minimizes the students' ability to develop higher order skills such as analysis, evaluation and synthesis of ideas and concepts. Studies 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, there is an abundance of literature that challenges educators to consider moving beyond the lecture method to active learning models which requires students to take greater responsibility in their own learning (1).

In general, most educators, including SH&E educators, would agree that an important goal of higher education is the development of both a desire for life-long learning and of effective problem solving (i.e., critical thinking) skills. Therefore, SH&E educators should consider minimizing the use of pure lecture

methods and instead begin to incorporate active teaching strategies that better prepare SH&E students for the complex and dynamic challenges they will encounter as practicing safety professionals.

The primary purpose of this paper it to explore the potential opportunities associated with problem-based learning (PBL), an active teaching strategy, in an SH&E curriculum.

Historical Background

PBL was developed as an alternative approach to the education of physicians and 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 (3). 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 (3). In problem-based learning, students collaborate to pursue solutions and knowledge they don't currently have and to study issues related to a problem and determine viable solutions. In this way, PBL is a holistic approach to complex higher education. PBL facilitates student achievement by supporting a structured process of using what one knows, systematically obtaining new knowledge and skills once gaps have been identified, collective application of new and old knowledge and skills and finally reflection. Thus, PBL has become both a teaching/learning method and a pedagogical philosophy.

What is PBL?

PBL is a learner-centered instructional method that enhances students' ability to analyze, synthesize, and evaluate problems. PBL can be described as a teaching strategy in which students confront contextualized, ill-structured problems and strive for meaningful solutions (6). PBL is an instructional method that utilizes 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 (4).

As a teaching methodology, PBL addresses a primary goal of education; that is to develop students who are effective problem solvers. The PBL curriculum delivery model recognizes the need to develop students to be effective problem solver and assist with the acquiring the skills and knowledge associated with a particular profession. Ideally, the PBL process culminates with students possessing skills and abilities that adequately prepare them for professional occupations where critical thinking, individual and group work is expected and complex problem solving skills are essential for success.

The PBL Learning Process

When engaged in the problem-based learning process, students are presented with a real-life scenario. They attempt to solve multi-faceted and complex problems with information they already know. They then determine what else needs to be learned; that is, they determine what they do not know or know how to do. Once they have determined what they need to learn, they engage in self-directed study, researching information needed to effectively address the problem and offer alternative solutions. After they complete the work on the identified problem, they assess themselves and each other to develop self-assessment and constructive assessment of peers (4). As a consequence, PBL integrates and develops all three domains of learning as described by Bloom, including the cognitive (mental and intellectual skills), affective (feelings and attitudes) and the psychomotor (skills) (5).

As a teaching methodology, PBL espouses learner-centered education as its primary goal. Further, PBL aims to develop students who are effective problem solvers and critical thinkers. A PBL-centered curriculum delivery model recognizes this aim and assists students in acquiring the skills and knowledge associated with a particular profession. In addition, PBL provides students with opportunities to solve problems by exposing them to ill-structured situations encountered by practicing professionals. This process produces students who can define problems, work out alternative hypotheses and develop reasonable solutions to the issues at hand. Students possessing these skills and abilities will be well prepared for professional occupations where critical thinking and problem solving skills are requisite for success. Ultimately, PBL attempts to produce students who can:

- Engage complex problems with initiative and enthusiasm.
- Problem-solve effectively, employing self-directed learning skills when needed.
- Continuously assess and acquire knowledge.
- Collaborate effectively as a group member.

In PBL, the instructor really functions as facilitator, not content expert (although he/she may be). Indeed, enacting the role of facilitator can explicitly reinforce to the students the need and fun in lifelong learning. PBL is a process and the instructor's role as facilitator is critical. The instructor has three main roles in PBL. First, the instructor assists in the development of questions students ask about the problem being investigated. Second, the instructor helps the students locate and understand appropriate references and resources. In this way, students clearly identify professionally appropriate resources of their field and can begin to apply them to the problem at hand. Third, the instructor assists in the creation of the "final product", or the proposed solution.

Adapted from Air Quality Curriculum Project from the University of Northern Arizona (11), the PBL process generally involves 7 steps described as follows.

1. **The Case or Problem Statement:** The facilitator will present an introduction to the issues, to establish a personal connection to the problem(s) for their students. This may take the form of a guest speaker, a video, a newspaper story, a photograph, or a written case study. This step provides the necessary background information to help the students place the significance and context of the problem and results in the ill-structured problem statement.

2. **The Questions:** The facilitator will lead 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? (the facts of the case)
    - What do we need to know? (other facts that are 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)

3. **Action Plan:** The groups of 3 to 5 student investigators then make plans for how they will find the information needed. Included in this plan is to develop a list of resources that may assist in the investigations. These resources may be published books or articles, community members or elders, or internet sources.

4. **Investigation:** The groups of student investigators carry out their action plans. Facilitators may also choose to have students do 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"….

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 probably be necessary.

6. **Final Product or Performance:** Each case concludes with a product or performance by the groups, or by subsets of the groups. Facilitators should provide the investigative teams with some possible options of products or performances. These may include plans for further action.

7. **Final Evaluation & Feedback:** The student investigators evaluate their own performance, their team's performance, and the quality of the problem itself. It is helpful here to have the students articulate what went well and what did not go well during the solution process and in this way, improve how the process initiates and progresses next time.

The question remains, would PBL be a helpful teaching methodology or philosophy for SH&E educators? The answer lies somewhat in the nature of SH&E education discussed next.

PBL and SH&E Education

The safety, health and environmental profession is characterized by complexity and change. From multiple and competing regulatory realities, to adult education and economic analysis, from understanding the near misses inherent in one's workplace to fatality investigations, from working with unions to top management, SH&E practitioners are constantly challenged by complex issues that may not have any obvious solution.

How best to structure the educational preparation of SH&E or risk control pre-professionals has been a long term challenge for educators in this field of study. Academics who teach safety, health or environmental and related content have had a long-standing, ongoing discussion regarding recommended student outcomes/competencies. Some SH&E educators feel that the primary thrust of safety education programs should focus on technical concerns. Primarily to assure content integrity, various accreditation organizations and systems, such as the Accreditation Board of Engineering and Technology (8) and certification bodies such as the Board of Certified Safety Professionals, (9)[1] have concurred with this position. There are others who argue that safety curriculum should be grounded in management. Lastly, there are proponents who suggest that safety curriculum should have a balance of managerial and technical content. While there is literature in the field that convincingly argues all sides of this particular issue, there is little to no research related to the process of curriculum delivery. What is commonly understood is that the SH&E curriculum can be characterized as broad in scope, as well as having both technical and social science underpinnings.

Straight away, the PBL curriculum delivery process complements the goals and challenges of SH&E educators. The interdisciplinary/multi-faceted nature of the SH&E curriculum and the SH&E profession

[1] To be more complete, the BCSP has re-organized the CSP exam to include 4 domains of professional responsibilities. One domain concerns ethics and another SH&E management. So, while the BCSP still values engineering and other technical aspects of the profession, they have also acknowledged non technical components of the profession as well. See http://www.bcsp.org/bcsp/media/exam_guide.pdf (10).

both lend themselves well to the PBL teaching model. As such, PBL encourages a more meaningful engagement by students 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 facilitates the instructor in achieving one of the most important goals of SH&E education, the development of students who are effective problem solvers (i.e., critical thinkers) and life-long learners. To better illustrate how PBL may be used in a SH&E curriculum, an example from healthcare safety is presented next.

Characteristics of Healthcare Safety

To see how healthcare safety may incorporate the tenants of PBL, let us begin by developing the nature of healthcare safety. In the past, the healthcare industry has received minimal attention from OSHA when compared to the general or construction industries. Little cost or injury data was available that highlights the significant safety problems known to characterize the healthcare industry. This phenomenon is about to change. The Occupational Safety and Health Administration is now actively reaching out to educate employers, healthcare workers and the general public about health and safety issues encountered in the healthcare industry. These issues include, but are not limited to: bloodborne pathogens and other biological hazards, exposure to various chemicals and/or drugs, domestic terrorism, waste anesthetic gas, latex and ergonomic exposures (7).

In general, OSHA, as well as healthcare workers, claims that education and training are critical to success in adequately addressing health and safety issues in the health care industry. If improvements will be made in the arena, occupational safety and health educators will have a pivotal roll. The problems encountered in the healthcare profession are numerous, complex and dynamic. For example, consider the following characteristics of hospital hazards; 1) the target audience for SH&E training is often highly educated and professionally accomplished (e.g., doctors, researchers, nurses) and as such, present specific challenges to the SH&E practitioner; 2) the health or safety 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 health and safety exposures often directly impact the health and safety of third parties, such as patients; 4) it is not uncommon for a healthcare hazard to include safety, health and environmental components (e.g., radioactive waste from chemotherapeutic agents).

Ultimately, and to better address such questions in the classroom, and thereby better prepare OSH pre-professionals, we propose that SH&E or risk control educators adopt the principle tenets of PBL[2].

Application of PBL to Healthcare Safety Issues

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 which may be controversial in nature.
- Lend themselves to higher order thinking according Bloom’s taxonomy including: **analysis** (simplifying material into its constituents in order to see inter-relationships) **synthesis**

[2] Clearly, the authors do not intend to suggest that PBL should be, or must be, limited to healthcare hazards. Indeed, most traditional areas of SH&E education are believed to be compatible with PBL. Instead, because healthcare hazards have a compelling and natural fit to the primary intentions of PBL, they are used as an example in this paper.

(producing new material from existing component parts) and **evaluation** (making judgments based on pre-set criteria).

Hence, SH&E or risk control educators face specific challenges in training practitioners to be able to successful identify and control healthcare hazards. An example of PBL in healthcare safety follows using the steps as described earlier.

Nursing Safety Example of PBL

Step 1 – The Case or Problem. Every day, nurses are exposed to numerous hazards at the worksite. These hazards include ergonomic exposures due to patient movement requirements, chemical hazards, occupational stress, workplace violence (especially in the emergency department), blood borne pathogenic exposures, bioexposures, radiation exposures, etc. While it is true that nurses get some degree of occupational safety and health training in nursing school, and that most hospitals are somewhat concerned about nursing safety, it is quite unclear whether and to what degree nurses can identify and are able to control the many hazards that comprise their professional work environment. So, as a hospital administrator, you know the financial consequences that result from uncontrolled, yet identifiable nursing hazards. How might you act to reduce to the extent possible, costs due to nursing-related healthcare hazards?

Step 2: The Questions. At this point, organize the students into working groups and help them identify what they know, what they don't know, and what they need to go learn. For instance, the students may want to know more precisely:

- The level of occupational safety and health training nurses receive in school and on the job.
- Accident and illness statistics for nurses over the past 5 years.
- What degree of cost savings is management really looking for?
- Are their union or organizational cultural issues of concern?
- What do the current job descriptions of nurses look like and do they include safety language?
- What is going on in peer institutions and has benchmarking been done?
- What engineering control measures exist now? Are they applied routinely? If not, why?
- Are there PPE or administrative control measures currently in place?
- What is the nature of the relationship between nursing working conditions, nursing job satisfaction levels, nursing turnover rates and the level of nursing hazards?
- Are there some exposures that can not be addressed?

Step 3: Action Plan. Students can now divide and conquer and determine how best to locate appropriate resources for things they don't know. Students should not be allowed to randomly proceed in this step. The instructor should guide them systematically. Students will then better see how a logical action plan is more efficient than a poorly thought out action plan.

Also, given the information that one can obtain on the Internet, it is a good idea here to help the student learn the difference between solid, responsible and appropriate resources and resources that are not professionally appropriate. This is also a good time to help students with organizational skills, note taking, and appropriate use of citations.

Step 4: Investigation. In this step, students are expected to implement the action plans determined above in step 3. Again, instructor facilitation of a logical, efficient approach is a teaching moment. Precise identification of who is responsible for what and by when is helpful. Indeed, the notion of a Gantt chart may be helpful.

Step 5: Revisiting the Questions. This is the recursive component of the process. At this juncture, students should stop and carefully consider what they know, what they still do not know, and what they may need to do to answer remaining questions. Students may need to go back and further investigate questions or unknowns, gather more information, or do more research before they're in a position to draw conclusions. The instructor can remind the students at this point of the notions of reliability and validity of data.

Step 6: Final Product/Performance. This step culminates the investigations into a final product such a report or presentation or both. The instructor has an opportunity here to assist students with professional writing and oral presentation skills as most professional projects should conclude with both a written proposal and an oral presentation.

Step 7: Final Evaluation. This step concludes the PBL process. The instructor has an opportunity to guide students through a post mortem of the PBL 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 so well and how/what subsequent improvements are indicated.

Conclusion

This paper introduced problem-based learning as a teaching philosophy and methodology applicable to SH&E curricula. The authors encourage SH&E educators to apply PBL methodology to their classes in order to obtain higher order learning and to bring SH&E issues to life. The role PBL forces instructors to take on is compelling and dynamic and allows one's students to observe and interact with the instructor in a more intimate and comfortable fashion than is possible with traditional lectures. PBL also requires a greater, deeper level of student involvement in class. Ultimately, PBL results in greater student learning, more class participation while providing students with the ability to see their instructors as mentors and guides, and not simply the "sage on the stage."

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