Problem-Based Learning in Nuclear Medicine Technology Education

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Problem-based learning (PBL) has emerged in the past several decades as an innovative educational approach used in the curricula of numerous medical schools internationally and in the United States. Currently, several allied health educational programs have begun to implement PBL methods in their courses. This research sought to ascertain whether or not PBL could be applied as an alternative instructional method in the education of nuclear medicine technologists. A problem-based instructional module on radiation protection was developed, and one unit of the module was implemented. All participants showed significant improvement on post-test scores in comparison to pre-test scores. In addition, all participants expressed enjoyment with this instructional approach in comparison with more traditional methods such as the lecture. PBL appears to be viable in the education of nuclear medicine technologists; however, further investigation into its use is encouraged.

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Problem-based learning (PBL) has emerged in the past several decades as an innovative educational approach used in the curricula of numerous medical schools internationally and in the United States (*1,2,3*). PBL is usually implemented in small group tutorials where students take an active role in the learning process and follow a specific sequence of learning activities. The learning content and objectives are structured around problems in professional or clinical practice rather than around disciplines (*4*).

PBL generally begins with an initial session where the learning content and objectives are presented to the students in the form of a written narrative problem. During this session, students (using an analysis model) analyze the problem by identifying the important data; asking questions; formulating hypotheses; and determining the learning issues to explore. Students then select one or two learning issues for individual self-directed study outside the classroom and gather resources and information about these learning issues. After a sufficient period, students return to the classroom for a session to synthesize their knowledge of the problem, exchanging and sharing the new information and knowledge acquired from their self-directed learning (*5,6*). Students are frequently required to perform a task or develop a solution to a problem as a group. In the next session, student learning is assessed and evaluated by the teacher.

The learning objectives for PBL commonly focus on the acquisition of certain skills, e.g., problem-solving and self-directed learning. PBL also promotes active student involvement in learning and encourages independent critical thinking, enhancing the students' integration of knowledge (*4*).

Several allied health educational programs are beginning to implement PBL methods in their curricula, namely, programs in physical therapy, nursing, occupational therapy, and physician assisting (*7,8*). Nuclear medicine technologists, like other medical and allied health professionals, are confronted with similar problems in areas such as patient care, administration, research, education, and professional activities.

The *Curriculum Guide for Nuclear Medicine Technologists* (*9*) recommends that students have opportunities to exercise administrative and management skills, practice teaching, and employ research techniques. Educators of nuclear medicine technologists need to utilize instructional methods that will encourage these kinds of learning experiences and activities. PBL is not mentioned in the professional and educational literature of nuclear medicine technology, although some schools or education programs may already be using variations of PBL as an instructional method.

Implementing PBL in the curricula should encourage the application of acquired knowledge in the context of professional practice to solve clinical, technical, and interpersonal problems. As a result, students may become better prepared for professional practice and to face the current challenges and changing demands of health care today. The literature in other fields has shown that implementing PBL may promote such skills (*10–12*).

Furthermore, nuclear medicine technologists, like other medical and allied health professionals, need to be updated

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and educated on new technology, science, and procedures occurring within the field. Implementing PBL in continuing education programs has the potential to encourage experienced technologists to think more independently and to apply problem-solving skills to construct viable solutions for real problems encountered in the profession.

This research addresses the question of whether or not problem-based learning can be applied as an alternative instructional method. A problem-based instructional module on radiation protection was developed and one unit of the module (radiation and the law), consisting of four class sessions, was implemented.

MATERIALS AND METHODS

Materials

Four nuclear medicine technologists (one female and three males) ranging from 24 to 42 years of age and with professional experience ranging from 2 to 13 years volunteered to participate in this research.

The unit was implemented over four class sessions. The setting for all sessions was the same; participants sat around a square conference table. Large newsprint paper, felt markers, and various other instructional aids and supplies were available for participants' use.

The learning content and objectives for the unit were derived from "Unit 28, Radiation Safety" of the *Curriculum Guide* (*9*). The learning issues focused on licensing and documentation required by government agencies for medical institutional use of radioactive materials.

The construction of the problem was modeled from principles and methods outlined from the medical educational literature on the construction of PBL problems. The problem was deliberately constructed, necessitating the preparation and completion of an application for amending a radioactive materials license. A list of references and resource materials was compiled, collected, and distributed to all participants. The reference and resource materials came from various sources including textbooks, journals, and publications from the U.S. Nuclear Regulatory Commission (NRC).

The format for analysis of the problem in the second session follows the format of the problem-based model used at Rush Medical College, Chicago, Illinois, and consists of the following.

1. Identifying the data.
2. Formulating questions about the data.
3. Generating hypotheses from the questions.
4. Determining and selecting learning issues.

The following instruments were used in this project for purposes of data collection and analysis.

1. Preproblem and postproblem multiple-choice tests (hereafter referred to as pre-test and post-test) were developed by the author. Questions were based on the reference and resource materials distributed to the participants.
2. The Glen Ellyn, Illinois, branch office of the NRC was used as the independent expert to review and evaluate the application for a radioactive materials license completed by the participants.
3. A participant satisfaction questionnaire was developed by the author. First, questions were selected from a list of course evaluation instruments provided in a University of Illinois publication (*13*). Second, selected questions were modified to encompass PBL in this project. The questionnaire consisted of seven questions. The first six questions were based on a rating scale of 1 to 5, with 1 representing the lowest score and 5 representing the highest score. The seventh question was an open-ended question that solicited feedback from the participants.

Methods

Prior to the first session, participants were given the following written materials: a letter of introduction about the research; PBL guidelines for participation; and two articles describing PBL (*5,6*). Participants were instructed to read all the materials prior to the first session.

The first session provided a brief overview and introduction to PBL. Participants were given a syllabus for the four class sessions and a review of the two articles and the PBL guidelines. Last, a PBL class exercise was explored, which consisted of breaking down the written case (data, questions, hypotheses, and learning issues). This was not the problem they would use for the remaining sessions.

In the second session, the participants took the pre-test. After the test, each student was given a written narrative problem. One participant volunteered to read the problem aloud to the rest of the group. The group then proceeded to analyze the problem. After analysis of the problem, each participant selected two learning issues, with some learning issues being taken by more than one participant, for independent, self-directed study. Following the class meeting, resources and references were reviewed and distributed in order to help students address the learning issues.

In the third session, the participants returned with their newly acquired knowledge and collectively answered questions and solved issues related to the problem (synthesis of the problem). The session ended when the participants decided that they had finished solving the problem, which was the completion of an application for amending a radioactive materials license to include iodine-131 for therapeutic use in the treatment of thyroid cancer. Participants took the post-test (two months after taking the pre-test) and filled out the satisfaction questionnaire.

Prior to the fourth session, the application that had been completed by the participants was given to the Glen Ellyn NRC office for review and evaluation.

The fourth session consisted of participant performance evaluation and feedback. The application was discussed, including comments and feedback from the tutor and the

TABLE 1. Results of Participant Satisfaction Questionnaire

Question	Mean Rating*
Were the resources provided adequate?	4.0
Was the learning climate stimulating and conducive to learning?	4.5
How much did you enjoy PBL compared to a traditional format (lecture)?	4.5
How much did you learn compared to other traditional courses?	4.5
Did PBL improve your ability to solve real problems in your profession?	4.25
How valuable is PBL as a method of instruction?	4.25

*The four participants rated their satisfaction on a scale of 1 to 5, 1 being the lowest degree of satisfaction.

NRC. Next, the pre-test and post-test were distributed and discussed; including participant results and answers. Finally, the participant satisfaction questionnaires were presented and discussed, as were my comments.

RESULTS

The pre-test and post-test each consisted of 20 multiple-choice questions; each question having 4 possible answers. The participants' pre-test scores were 22%, 39%, 56%, and 28%. The post-test scores were 56%, 67%, 61%, and 56%. The pre-test and post-test scores of each participant were added together and the mean score computed. The mean participant score for the pre-test was 36.25% and for the post-test it was 60%. The Angoff method (*14*) was used to determine the passing score for each test. The passing grade for the tests was 55%. One of four participants received a passing grade on the pre-test, while all participants received a passing grade on the post-test.

The radioactive materials license application completed by the participants was reviewed by a staff member in the radioactive materials licenses section of the Glen Ellyn office of the NRC. The application was treated and reviewed like an actual license application. The license application submitted by the participants contained a total of 13 items, which had been completed. The NRC reviewer decided that 2 of the 13 items needed some additional information. A mock license was issued and a time allocation was given in which to submit the additional information requested by the NRC reviewer.

The satisfaction questionnaire asked the participants to rate six questions (on a scale of 1 to 5, 1 being the lowest degree of satisfaction). The scores of each participant for each question were added and the mean computed. Table 1 presents the mean participant rating for each question.

The seventh question in the questionnaire was open-ended. Participants were asked to make comments on the best and worst features of their experience with PBL. The participants identified three features that they liked best.

1. Group discussion and the exchange of ideas (n = 2).
2. Learning enhancement (n = 1).
3. Increased motivation and interest in the learning experience through group participation (n = 1).

The participants also identified three features that they liked least. (One participant gave no response to this question.)

1. Abundance of information (n = 2).
2. Difficulty in studying the material alone (n = 1).
3. Some inadequacy in the presentation of the problem, (lack of an existing license), making it a little difficult to solve the problem (n = 1).

DISCUSSION

A central focus of this project was to determine whether PBL principles could be applied to nuclear medicine technology education. This project indicates that PBL can be applied; problem-based instructional modules for nuclear medicine technology can be developed and implemented, resulting in both student satisfaction and student achievement.

Another focus of this project was to determine how satisfied students were with PBL. Table 1 shows that the overall satisfaction of the participants was favorable. Some of the participants' comments from the questionnaire also lend support to their preference for active learning as opposed to sitting and listening to a lecture.

The comments from the NRC show that the participants were relatively successful in accurately filling out and completing the application for amending a radioactive materials license. Unfortunately there was no time for the participants to resubmit the items noted as deficient by the NRC reviewer. In an actual classroom situation, time could be allocated for students to do this.

Since the participant sample size was small and did not include students enrolled in a formal class, there is a need to expand this project to include a larger number of students taking formal classes; this will add to the project's validity.

The implications of implementing PBL in nuclear medicine technology education are numerous. First, PBL could be adapted in the education of nuclear medicine technologists. This learning approach could be used in a variety of content areas. It could be modified to include numerous educational tasks, such as preparing a departmental operating budget or studying the medico-legal aspects of the profession.

Second, one or more instructional PBL sessions could be incorporated into traditional lecture courses with a focus on one or two major problems. For example, the instructional problem-based unit on radiation and the law developed for this project could be used in a course on radiation protection. In addition, PBL learning sessions could be developed around current problems, such as departmental quality assurance programs or customer service programs.

Third, problem-based instructional methods could also be incorporated into laboratory courses. For example, a problem could be designed around personnel or area decontamination situations, wherein students would not only have to know the procedures and techniques but actually perform them in order to solve various problems.

Fourth, PBL methods could bring new life and excitement to continuing education programs for technologists as well as physicians, offering different learning opportunities and experiences that could be applied to their own professional situations. For example, problems could be designed around practical issues and current concerns, such as federal or state inspections, use of investigational radiopharmaceuticals, or planning and training for use of PET.

CONCLUSION

This project provided insight for future development and implementation of PBL in nuclear medicine technology education. Educators thinking of using PBL should start by developing brief PBL experiences for students, encompassing at least two class sessions. Educators who are inexperienced with problem-based teaching and learning methods should begin with short and simple problem-based learning experiences until they and their students are more familiar with this method of instruction. Later, instructional units and modules can be developed and implemented. In addition, both faculty members and students should receive some training and instruction in PBL principles and methods. Finally, rather than reinventing the wheel, nuclear medicine technology educators should borrow and adapt from what has already been developed and implemented in other fields.

The benefits of PBL, such as active learning, integration of learning, and development of problem-solving and self-directed learning skills, could not only enhance the preparation of students for professional practice but also give them the skills and knowledge necessary for continued development and growth in their careers.

In a recent article, Bruhn states that allied health educators should use PBL in preparing future allied health practitioners (*8*). He notes that "the allied health practitioner who remains competent despite change will be a self-directed learner and critical thinker who is sensitive to the human side of practice; [is] comfortable working with peers in other disciplines; and [has] management and organizational skills."

The willingness of allied health educators and program directors to learn and develop new teaching skills and instructional methods associated with PBL is unknown. Another unknown variable is whether they would devote the time and effort necessary to prepare and implement problem-based instructional units and learning experiences. However, at the very least, educators should become more familiar with PBL in order to make an informed decision on its use.

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