The Internet Journal of Allied Health Sciences and Practice
http://ijahsp.nova.edu
A Peer Reviewed Publication of the College of Allied Health & Nursing at Nova Southeastern University
Dedicated to allied health professional practice and education
http://ijahsp.nova.edu Vol. 1 No. 1 ISSN 1540-580X

Problem-based Learning in Allied Health and Medicine

Todd A. McLoda, Ph.D., ATC/L
Illinois State University
Normal, Illinois
United States

CITATION: McLoda TA: Problem-based Learning in Allied Health and Medicine. The Internet Journal of Allied Health Sciences and Practice. 2003. Volume 1 Number 1.

ABSTRACT
This paper reviews the applicability and procedures for the adoption of problem-based learning in allied health and medical education. A summary of PBL as a practical innovation for professional preparatory programs is included as well as an overview of the features and evaluative techniques of PBL. The paper is directed at PBL in health and medicine but those educators seeking to enhance integrative thought processes, problem-solving, creativity, critical thinking, interpersonal communications, and resourcefulness among students are advised to consider PBL as an alternative approach to teaching and content delivery.

INTRODUCTION

Problem-based learning (PBL) is an approach to learning that emphasizes the process rather than the simple acquisition of knowledge. Boud and Feletti describe PBL as a means of "structuring the curriculum which involves confronting students with problems from practice which provide a stimulus for learning."[1] This concept of learning through doing has been used for education in business, architecture, and law. The focus of this article is on the applicability of PBL to health sciences and to medicine. More specifically, this review will concentrate on PBL as an approach to meeting the challenges of an ever-changing information base as well as promoting the viability of health care practitioners throughout their careers. The underlying capabilities necessary for viability in these professions include integrative thought processes, problem-solving, creativity, interpersonal communication, and resourcefulness. An overview of the approach as an innovation in teaching is offered and the unique components of PBL are described.

THE IMPETUS FOR CHANGE

The changes that took place in health care through the 1990s have been well documented. The focus moved from reactive care toward preventive care. Knowledge in health care increased at a staggering rate. Information became obsolete in as little as 12 months. Educational program directors developed concern for whether educational programs were adequately preparing practitioners to be increasingly adaptable to changes in health care. Several medical schools and allied health education programs foresaw these challenges and altered instructional approaches to medicine to promote students as lifelong learners.[2-6] A major criticism of traditional lecture-based education was the encouragement of "a static, passive attitude toward education that emphasizes memorization instead of the active, inquiring cast of mind required to keep up in a rapidly changing field."[3] Traditional lecture-based education is driven by the instructor, who controls content delivery. Coles notes that much of allied health or medical education is memorization of facts and data, often composed of abstract information, which is to be applied clinically at a later time.[7] Coles asserts, "students experience overload, lose their motivation, find it difficult to see the relevance of what they are being taught, and later on experience difficulty in retrieving and applying in a clinical setting the information they learned early on." Boshuizen & Schmidt suggest that although the health care provider possesses the knowledge, he or she may be unable to access it during application, especially in actual field or clinical settings.[4]

Recently, more innovative techniques for making the student responsible for his or her own learning have been recognized.[8] Curricular innovations in health care education were adopted to improve the adaptability of graduates. These innovations were based upon well-defined theory and strategies and were somewhat experimental in nature. There was no single approach or solution being implemented by medical schools. Each school developed unique characteristics. Some schools implemented more than one distinct curriculum model in an effort to evaluate the best qualities of the models.

Problem-based learning (PBL) received much of the attention. Several medical schools and allied health science programs changed their curricula to incorporate one or more aspects of PBL in an effort to improve both the short-term and long-term cognition of the respective graduates of the programs.[3,6,9-11] Other educational programs such as those in architecture, law, educational leadership, and secondary education, adopted or adapted PBL either to strengthen existing perspectives of the program or as an altogether new approach. Many education programs, regardless of the discipline, require some problem-based learning. However, it is unique when this learning approach is used as the primary approach to instruction. Lipkin notes two encompassing reasons why one medical school in particular elected to examine PBL.[5] One reason is an increase in the motivation level of the students because they would be working with information directly related to their choice of profession. The second reason is that the problem-solving abilities of the graduates, and in turn, their creative abilities, would improve in such a program. Each of these abilities is believed to be vital to medical professionals. Lipkin asserts that the pioneers of this medical school "anticipated outcomes of improved learner satisfaction, more relevant and better organized learning, and thereby improved and better sustained clinical performance". Schmidt notes prior research by Barrows and Tamblyn when he reasons that medical students are adept at acquiring the knowledge of medical school, but lack the ability to apply that knowledge clinically.[12,13] This has further led medical schools, as well as other disciplines, to seek alternatives to traditional curricula. One such alternative is problem-based learning.

THE ADMINISTRATION OF PBL

Problem-based learning is a departure from the traditional educational paradigm where a group of students convene for a class that is directed by an instructor. The instructor may lecture on a subject or engage the class in interactive activities such as discussion, small-group assignments, or demonstration. The emphasis is instructor driven. With PBL, the students meet as a small group of typically six to eleven and are guided by an individual referred to as a tutor. The group of students is presented with a complex problem developed by a panel of tutors who are experts in a selected field. The problem may be in written form or could be a simulation of some sort. The group discusses the problem typically for a period of 1 to 3 hours. It is during this time that learning objectives are established by the group. The group also determines what relevant information is necessary in resolving the problem. The role of the tutor is to facilitate the conversation while allowing adequate time for individual thought and reasoning. At the conclusion of this initial meeting, the students explore the information necessary to solve the problem scenario.

This self-directed learning phase generally takes 2 to 3 days while the students research data, observe models or specimens, or attend lectures in an effort to obtain knowledge to solve the problem. The small group then reconvenes to continue the discussion and present the new data. Schmidt calls this second meeting a time for "synthesis" where the students exchange ideas in resolving the problem.[12] The tutor again takes the role of the facilitator and suggests probing questions to enlighten the conversation of the group. Once the problem is resolved, a new problem is presented with perhaps a different tutor advising and facilitating the group. This process continues until learning objectives are met at which time the students are evaluated on the knowledge acquired in the particular unit.

The type of learning that takes place with PBL is considered more enduring because the learning process is more relevant to the student and the learning is self-directed; that is, the student is responsible for the learning of the content material. Many would argue that this leaves the unmotivated student vulnerable to failure; however, it is reasoned that the support received from the group as well as the desire to not disappoint the other group members would be sufficient to keep students on task.

DEVELOPMENT OF EDUCATIONAL CONTENT IN PBL

Sibley lists six criteria which must be met in the development of problems for a PBL environment: prevalence; treatability; prototype value; interdisciplinary input; length; and format.[11] Prevalence refers to how frequently the problem would occur in actual practice. Rare problems, although useful at fostering deep insight among students, have less direct relevance for the students. Majoor, et al emphasize that problems must motivate students for further study and clearly link with future career goals of the student.[14]

Treatability assumes that evidence exists to support the rationale that treatment of a disorder contained in a problem is positive and therefore warranted. This will become known in the development of the problem because all problems are ultimately criterion-referenced, that is, they are solved by the expert developers for later evaluation and comparison to student responses. Treatability in problem-based learning supports the inclusion of evidence-based practice which involves the collection and interpretation of findings to support validated conclusions regarding the problem or case.[15]

Klassen, et al indicate that in order for the student to operationalize evidence-based practice, he or she must be exposed to research methods throughout the curriculum rather than in a single course.[16] Applying a research process to the resolution of a clinical problem reinforces not only the learning of the problem content but the appropriate process of reasoning, collecting information, synthesizing evidence, and deriving a conclusion to solve the problem. Therefore, an emphasis on the treatability of the problem in terms of evidence-based practice supports the development of an effective lifelong learning style.

Prototype value allows for the inclusion of experimental problems or problems that are currently poorly understood. This type of problem elevates the cognitive reasoning of the students because students must probe deeply and rationalize pure hypotheses when solving problems that have not been previously solved. These problems are therefore not criterion-referenced but are evaluated on the basis of theory development and insightful thought processes. Thomas maintains the position that prototypical problems are useful as introductory problems because they typically involve more features than standard-format problems.[17] Thomas also notes that the inclusion of distracters or extraneous information in problems is useful to the learning process of the students because in actuality, most patients will provide information to a health care practitioner that is not relevant to the case. The overall content of the problem must not exceed the previous learning of the students to the point that the problem will be considered unsolvable by the students.[14]

The interdisciplinary input of a problem refers to the inclusion of several disciplines within a profession in the development of the problem. In medicine, for example, this is possible through the inclusion of more than one of the categories of sciences identified by Barr 9. For example, a problem that includes psychology, anatomy, physiology, and biomechanics would cross several disciplines and would also require the students to take an interdisciplinary approach to problem resolution. The developers of the problems must take care to prevent problems that are too multifaceted to be solved under ordinary conditions.[17]

The length of a problem must be carefully monitored during development. Sibley notes that problems that are too long cause students to become overwhelmed and no longer motivated to solve the problem.[11] Conversely, problems that are too short do not sufficiently challenge the students and are therefore not desirable. Majoor et al. counter that shorter problems are better for small groups of students because they tend to more readily inspire discussion among the group members.[14]

Finally, the format of the problem is the final consideration Sibley lists.[11] The format of a problem implies how the problem is presented to the students. Sibley notes that students prefer problems that are realistic. Students also prefer that faculty not list questions with the problem as this detracts from the thought processes of the students. Questions formulated by faculty tend to cause the students to focus on certain aspects of the problem rather than proceed to brainstorming for hypotheses and developing learning objectives. Problems should provide students with only a portion of the information necessary to evoke clinical reasoning skills and thought processes.[18] Sibley also recommends that problems be submitted to students by means of a variety of media including, where appropriate, case protocols, problem boxes, card decks, and simulated scenarios. Good problems will cause students to apply technical skills necessary for resolution.

THE TUTOR IN A PBL PROGRAM

The role of the tutors involved in PBL curricula has prompted several studies. Issues included whether the tutor should be an expert at tutoring, whether the tutor should be an expert in the subject matter, the degree to which the tutor should facilitate the group process, whether the role of tutor is best accomplished by a faculty member or by an advanced student, and the method used to evaluate the group by the tutor and the tutor by the group. Various studies have addressed one or more of these issues but agreement on the issues does not seem to exist. Barrows and Tamblyn strongly advocate the use of tutors well-versed in the process of coordinating a small group.[13] In one study, the investigators state “tutors are expected to be experts in the process of small-group facilitation but not necessarily in the content of the problem to which a solution is sought.”[19] The same investigators cite previous research when they conclude overall that the tutor is the key to the PBL process, the tutor is best an expert at tutoring and secondly an expert in the subject matter of the problem, and faculty members as tutors tend to enhance student learning better than peer tutors. The peer tutors are generally students in the advanced phase of the curriculum, such as a fourth-year medical student. Eagle, et al note that the possible reasons for the preference of expert tutors was that they can better challenge the students and recognize when the group needs assistance in meeting learning objectives. A study conducted by Schmidt, et al supports the belief that a tutor should be an expert in the subject area of the unit and therefore the role is best accomplished by a faculty member rather than a peer tutor.[20] Schmidt et al indicates that the faculty tutor offered more to the group because he or she contributed more and asked more stimulating questions than his or her student tutor counterparts.[20] Also, the investigators note “a small but statistically significant effect on achievement.” Specifically, the students in the group conducted by a staff tutor performed better on an examination than the group conducted by a student tutor. These findings are refuted in a similar study conducted by Moust and Schmidt.[21] The investigators found student tutors are preferred to the faculty tutors by the group members since “student tutors seem to be better able to ‘speak the language of the students’, they appear more competent in offering the members of their small tutorial groups suggestions that the first-years can comprehend.” Of course, the investigators maintained that although student tutors can be an asset to the small-group tutorial process in PBL, the student tutor must possess content expertise.

In a paper by Holmes and Kaufman, several recommendations are made for the successful recruitment and training of PBL tutors.[22] The authors cite one method for recruitment was appointment by department heads while another popular method was for tutors to volunteer. Holmes and Kaufman place no strong emphasis on whether the tutor needed to be an expert in the subject of the problem. Instead, they tend to recruit non-experts, deviating from the recommended approach of Barrows and Tamblyn and of Eagle et al. previously noted. The explanation given for this deviation was that when recruiting new tutors for a fresh curricular approach such as PBL, a subject expert may not be able to refrain from resorting to traditional teaching techniques such as lecturing when the small group seems to be struggling with a particular topic. Holmes and Kaufman outline seven stages to training new tutors for their role. The process begins with an initial workshop and continues with regular meetings to discuss triumphs and ordeals. An evaluation component is built into the process as is a continuing education component which focuses on input from the veteran tutors for self development as well as program development.

Most studies of the tutoring process in PBL include an evaluation component which takes on several forms. The tutor of the small-group in PBL, although somewhat passive, takes on a vital purpose in the process. The facilitation or small group process skills of the individual tutor must be adequately evaluated to ensure quality is maintained. The recommendations made by Holmes and Kaufman 22 include an evaluation made by the students at the end of a unit and random evaluations conducted by the tutor training group. This seems to be the norm in evaluating tutors although several researchers noted that tutor evaluation should be performed more frequently.

STUDENT ASSESSMENT IN THE PBL PROGRAM

While evaluation of the tutors who facilitate the PBL groups is noted to be an important component of an effective PBL program, probably of more vital interest is the assessment of the students in the PBL program. Neufeld and Sibley define evaluation as “the precise or approximate determination of the value, the quantity, or the cost from which value judgments are made in reference to available standards.”[10] The differing techniques of assessing students in a PBL curriculum presents a challenge for those who wish to determine the best approach. If the “task for the student should be the development of ability in the processes of critical thinking and the application of knowledge to the solution of clinical problems, rather than the acquisition of knowledge for its own sake” what are the best methods of assessing this development and application?[23] Patel asserts that prior knowledge of the student, especially in the basic sciences, plays a major role in the learning that takes place in a PBL environment.[24] Given this statement, it seems evident that a pre-test should be administered to students to determine their starting level of knowledge.[24] Of course the emphasis in PBL is for students to learn how to learn but it becomes apparent that, following the organization flow for a system which includes the components of input, process, and output, a program can be viewed as only as good as its output.

De Vries describes a need for both formative and summative student assessment techniques in a PBL program.[25] The formative methods allow students to learn from mistakes and process that information into knowledge while the summative methods ensure that the program is accountable to the consumers of its graduates (those that hire the professionals) in that they are competent. Throughout each unit, students are typically evaluated by written examinations. These examinations allow the students to gauge their progress and are therefore not included in the unit grade.[26] Throughout much of the typical PBL program, pass or fail are the only categories of grades given. Neame notes that this practice is used to avoid competition between the individual members of a group and to therefore promote teamwork.[6] Bridges and Hallinger also rely on the grades of pass or fail but note that if a particular institution prohibits the use of such grades, a more conventional five-point grading scale may be adopted.[27] The actual measurement tools frequently include short answer items, objective clinical assessments, and case studies.[6] Neame also notes that the items on the examinations are criterion-referenced, that is, experts answer the items in advance of the students taking the examinations. Other programs utilize simulations for the purpose of student assessments. Bridges and Hallinger advocate the use of simulations and case studies because the methods most closely resemble the tasks of PBL and the examinations are more relevant to real world situations.

The coordinators of PBL curricula, whether in a pure form or merely taking on strategies of PBL, place an emphasis on assessing the problem-solving capabilities of the students as well as their ability to learn on their own. This deviates from the practice of traditional assessment approaches where the emphasis is on recitation of facts on objective or subjective format examinations. Some advocates of PBL also support the use of distinctly controversial forms of student assessment. The methods are controversial because they are not commonplace and are thought to be experimental. Such methods include assessment tools developed by the instructor but evaluated by the student or tools that are both developed and evaluated by the student.[27] These tools may take the form of essays in which students discuss what has been learned in a given unit. Students may also develop what Bridges and Hallinger refer to as protocols, "instructions, guidelines, or checklists that professionals may use to guide their performance." A third such tool for innovative assessment is process activities whereby a student would verbally ascertain the steps involved in a given process for the purpose of solving a problem. This example can be most closely compared with the simulations discussed previously. Although experimental in nature, the proponents of these methods praise them as worthy alternatives to more traditional methods.

PROGRAM EVALUATION OF A PBL CURRICULUM

Of a parallel concern relating to the assessment of the students in a PBL curriculum is the evaluation of the program itself. Methods have been developed by the programs which have adopted PBL and it is important to consider the methods because of the innovative nature of problem-based learning. The most basic techniques are those of faculty and student questionnaires. These are used frequently by the various PBL programs almost seemingly from a lack of confidence in the techniques being used. The program administrators are, of course, committed to the faculty and students with regard to program quality but there seems a limit to the usefulness of repeated opinion questionnaires from these two groups. It seems likely that program evaluations completed by practitioners who completed the program as well as consumers of those practitioners would be a more beneficial alternative. Neufeld and Sibley note that if a given program is to be successful, it must be held accountable in input--student selection criteria, faculty recruitment, and resource allocation; process--educational program development, student assessment, faculty evaluation; and finally output--"the performance and acceptability of the product of the program."[10]

There seems to be no present criteria established for the selection of students to a PBL curriculum. For example, at Maastricht, a Dutch medical school, students are admitted with varying backgrounds, not necessarily science-related, and the students perform equally as well as students carefully admitted on the basis of requisite knowledge at other schools.[28] The PBL medical school at McMaster University in Canada produced no significant correlation between the entering grade point average of students and course performance.[10] Similarly, Neufeld and Sibley indicate that McMaster could demonstrate little correlation between student success of those with a science background and those with a non-science background when adjusting for age.

With respect to faculty recruitment, the common practice among PBL programs is to focus more so on faculty development. Schmidt indicates that faculty development in problem-based learning requires instructors to forego a number of beliefs rooted in the practice of traditional methods and foster new skills intended to contribute to the improvement of a curriculum.[29] This process of faculty development may be vital for faculty in medical schools where many of the faculty are trained as physicians or scientists and not as teachers.[29]

Resource allocation is also an important input factor to be considered with PBL. The general belief is that innovations in education cost more, both in terms of actual dollars spent and time allocated. Mennin and Martinez-Burrola conducted a study to determine the relative costs of a PBL curriculum compared to a traditional curriculum.[30] They reasoned that much of the costs associated with medical and allied health education were faculty salaries and therefore, a study demonstrating how faculty time was spent could reveal the costs of a PBL program. The comparisons were conducted at the University of New Mexico Medical School where both a traditional and PBL track co-exist as separate curricula. The investigators found that in the traditional curricular track, faculty members spent on average, 61% of their time preparing for instruction and 39% of their time in actual contact with students. Conversely, in the PBL track, the investigators noted that faculty members spent 28% of their time preparing for instruction and 72% of their time in actual contact with students. Also factored into the cost was time allocated to the training of faculty members who were to assume non-traditional roles in PBL. Training time was calculated into preparation time because there was no contact with students. Mennin and Martinez-Burrola concluded that there was not the perceived increase in time spent by faculty members in a PBL curriculum. Faculty roles in PBL centered around activities including developing cases and problems for the curriculum, serving as facilitators of the learning groups, taking the role of content experts, and evaluating the students. Mennin and Martinez-Burrola note that these activities take less time than lecture preparation and delivery, characteristics of a traditional lecture-based education.

There are other costs of a PBL curriculum which must be considered when adopting strategies of the approach. Barrows and Tamblyn note that students must be afforded time which is otherwise unscheduled so they may assess learning objectives and seek the necessary information for problem resolution.[13] This time may be spent meeting with faculty members who are content experts for the current problem, attending special lectures, viewing multimedia materials, attending laboratory sessions, or visiting the library. These are vital considerations in self-directed, PBL curricula.

Barrows and Tamblyn note also that because students require various materials to carry out learning objectives, faculty members must amass a variety of materials and provide time for student access.[13] This factor must be calculated in to the resource allocation for PBL environments but is probably similar to the amount of materials required by faculty in traditional curricula who must prepare a variety of materials for lectures, demonstrations, and laboratory experiences. Barrows and Tamblyn emphasize that well-thought planning and preparation can offset the burden of establishing the learning modules of related problems necessary for a PBL curriculum.

Professional preparation programs, including those in the health sciences and medicine may benefit from the attempts by other institutions to include PBL as an educational innovation to keep stride with the ever-changing knowledge in this information age. The PBL approach to learning places an emphasis on integrative thinking, problem-solving, creativity, interpersonal communication, and resourcefulness. Health science and medical education programs with the insight to capitalize on the benefits of PBL will surely prepare students for a changing society and ultimately become the model educational programs for others to follow.

REFERENCES

1. Boud D, Feletti G. The challenge of problem-based learning. 2 ed. London: Kogan Page Limited; 1997.
2. Knopke H, Diekelmann N. Approaches to teaching in the health sciences. Reading, MA: Addison-Wesley Publishing Company; 1978.
3. Bok D. Needed: A new way to train doctors. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:17-38.
4. Boshuizen H, Schmidt H. The developing structure of medical knowledge. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:218-240.
5. Lipkin M. Toward the education of doctors who care for the needs of the people: Innovative approaches in medical education. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:3-16.
6. Neame R. Problem-based medical education: The Newcastle approach. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:112-146.
7. Coles D. Evaluating the effects curricula have on student learning: Toward a more competent theory for medical education. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:76-87.
8. Dolmans D, Schmidt H, Gijselaers W. The relationship between student-generated learning issues and self-study in problem-based learning. Instructional Science. 1995;22:251-267.
9. Barr J. A problem-solving curriculum design in physical therapy. Physical Therapy. 1977;57:262-272.
10. Neufeld V, Sibley J. Evaluation of health sciences education programs: Program and (student) assessment at McMaster University. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:165-179.
11. Sibley J. Toward an emphasis on problem solving in teaching and learning: The McMaster experience. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:147-156.
12. Schmidt H. Problem-based learning: Rationales and examples. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:101-111.
13. Barrows H, Tamblyn R. Problem-based learning: An approach to medical education. New York: Springer Publishing Company; 1980.
14. Majoor G, Schmidt H, Snellen-Balendong H, Moust J, Stalenhoef-Halling B. Construction of problems for problem-based learning. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:114-122.
15. Wynd C. Evidence-based education and the evaluation of a critical care course. J Contin Educ Nurs. 2002;33:119-125.

16. Klassen P, Karshmer J, Lile J. Research-based practice: Applying the stardard in nursing education. J Nurs Educ. 2002;41:121-124.
17. Thomas R. Teaching medicine with cases: Student and teacher opinions. Medical Education. 1992;26:200-207.
18. Walton H, Matthews M. Essentials of problem-based learning. Medical Education. 1989;23:542-558.
19. Eagle C, Harasym P, Mandin H. Effects of tutors with case expertise on problem-based learning issues. Academic Medicine. 1992;67:465-469.
20. Schmidt H, van der Arend A, Kokx I, Boon L. Peer versus staff tutoring in problem-based learning. Instructional Science. 1995;22:279-285.
21. Moust J, Schmidt H. Facilitating small-group learning: A comparison of student and staff tutors' behavior. Instructional Science. 1995;22:287-301.
22. Holmes D, Kaufman D. Tutoring in problem-based learning: A teacher development process. Medical Education. 1994;28:275-283.
23. Thompson D. Reactions to the introduction of problem-based learning into a medical school: Faculty and student views. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:165-174.
24. Patel V. A cognitive science perspective on instructional issues. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:189-203.
25. de Vries M. Evaluation in innovative medical education. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:157-163.
26. Baca E, Mennin S, Kaufman A, Moore-West M. Comparison between a problem-based, community oriented track and a traditional track within one medical school. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:9-26.
27. Bridges E, Hallinger P. Implementing problem based learning in leadership development. Eugene, OR: ERIC Clearinghouse on Educational Management; 1995.
28. Verwijnen M, van der Vleuten C, Imbos T. A comparison of an innovative medical school with traditional schools: An analysis in the cognitive domain. In: Nooman Z, Schmidt H, Ezzat E, eds. Innovation in medical education: An evaluation of its present status. New York: Springer; 1990:40-49.
29. Schmidt H. Faculty development. In: Schmidt H, Lipkin M, de Vries M, Greep J, eds. New directions for medical education. New York: Springer-Verlag; 1989:239-241.
30. Mennin S, Martinez-Burrola N. The cost of problem-based vs. traditional medical education. Medical Education. 1986;20:187-194.