Review Articles

Problem-based learning

A critical review of its educational objectives and the rationale for its use

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ABSTRACT

Over the past 30 years there has been an increasing interest in curriculum innovation in medical schools in North America, the United Kingdom, Netherlands, and Australia. Since the introduction of problem-based learning at McMaster University in Canada in 1969, several medical schools throughout the world have adopted problem-based learning as the educational and philosophical basis of their curricula. Several studies have shown that problem-based learning is an important educational strategy for integrating the curriculum, motivating the students and helping them to identify their learning issues and set their own learning goals. However, there is a great deal of concern regarding what problem-based learning means and the advantages of problem-based learning over traditional curriculum have not been clearly addressed. In this review, a broad range of the definitions of problem-based learning have been addressed and the rationale for problem-based learning and its educational objectives are discussed.

Keywords: Problem based learning, medical curriculum, self-directed learning, small group.

Neurosciences 2001; Vol. 6 (2): 83-89

A primary goal of problem-based learning (PBL) is to foster clinical reasoning or problem-solving skills in students.[1] Problem-based learning is an approach to professional education that has been based on research into how adults learn most effectively.[2] This approach was first introduced into medicine at McMaster University in Canada in 1969. A few years later, 2 universities adapted the PBL approach to medical education, the University of Limber at Maastricht, the Netherlands in 1974 and the University of Newcastle in Australia in 1976.[3-9] Since then the use of PBL in medical education has been endorsed by the World Health Organization,[10] the Association of American Medical Colleges and the World Federation of Medical Education.[11-12] Problem-based learning is now an entrenched component of medical school programs in the United States, Europe, the Middle East, Africa and Asian/ Pacific nations and other universities in Australia (the Flinders University of South Australia, the University of Sydney, the University of Melbourne).

Problem-based learning is an approach to learning that uses a problem to drive the learning[13,14] rather than a lecture with subject matter, which is taught.[15] In PBL programs, a set of problems is used to engage the students in learning in small groups. A framework for PBL curriculum is usually designed by an executive group, which sets the scope and major theme for each semester. Students then identify the salient features of the problem, the areas in which they lack information needed to understand the problem and how best it can be approached and dealt with. These problems are presented to students to solve prior to teaching them basic science or any

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information needed to solve the problem.[16] Hence, PBL acknowledges the possibility of prior knowledge (whether from secondary school education, previous PBL cases or other forms of learning within the science, medical or psycho-social schools).[17] Further knowledge is acquired on a "need to know" basis, enabling the learner to identify their own learning needs. Knowledge gained is fed back into the problem.[18] In this way PBL allows the learner to identify learning topics and discipline related to the problem. One advantage of this approach is increased motivation.[14]

What does PBL mean? Problem-based learning may be best thought of as a syndrome comprising of a number of components.[12] The term "case-based learning" is sometimes used rather than PBL. The latter term, despite its international currency, is not ideal; not all cases are problems, and solving these "problems" is not the primary purpose of the exercise.[12,18] According to Barrows (1986), the term PBL can have many different meanings depending on the design of the educational method employed and the skills of the teacher.[19] Barrows (1986) states that there is no single version of PBL and he has attempted to classify forms of PBL using a taxonomy.[19] Other authors agree that there are varying forms of PBL and changes may be implemented in the format and models of problems to enable students to go into more depth.[14,20] Table 1 summarizes available definitions of PBL in the medical education literature. Although these definitions seem to address a common ground, they raise several issues for dispute over what constitutes PBL. For instance, the notion that PBL enhances the process of acquisition of problem-solving skills has been disputed.[24,25] Recently, the issue of whether PBL should fulfill the items included in these definitions has been raised.[26] It is also of interest to note that several variations or models of PBL have been developed, and there is ongoing argument regarding which models are legitimate applications of the principles and which are sufficiently distinct to be outside the legitimate field of PBL.[26,27] This diversity in the definition of PBL is due to the fact that PBL is still an emerging concept. Differences in the perception and beliefs held regarding PBL by its practitioners have also contributed to this diversity. Lloyd-Jones et al and Folly et al found numerous articles that described PBL programs in undergraduate, graduate and continuing medical education, but only a handful met the criteria outlined in Barrows' taxonomy of PBL.[19,28,29] These authors concluded that the inappropriate utilization of the term has now become a serious problem of PBL programs. Regardless of these differences, a number of clinical stages or steps are usually considered in the PBL process (Table 2). The problem usually begins with a trigger text or a scenario, which is often presented to the students without preparing them. A series of images, a 2-3 minute video or a cartoon may accompany the trigger text. The following example of a trigger text has been used in one of the problems we have developed for the new medical curriculum at the Faculty of Medicine, Dentistry and Health Sciences.

"Mr. Bill Smith, a 48 year old invalid pensioner, is brought to the Emergency Department of a Melbourne hospital by ambulance one evening. He is pale, drowsy and is holding an emesis bowl filled with fresh blood. The ambulance officer tells you that Mr. Smith's neighbor had called for the ambulance. She had heard a loud crash and had gone into Mr. Smith's flat to check if he was alright. She found him lying on the bathroom floor. He was conscious but drowsy. There was a large amount of fresh blood in the toilet and some blood in his beard. Mr. Smith is able to answer your questions and tells you that he hasn't been feeling too well for the last few weeks. His belly has felt uncomfortable and has gradually become so swollen that he can't do up his trousers. This morning he vomited some material that looked like coffee grounds and tonight he vomited blood. The next things he can remember is his neighbor finding him on the bathroom floor."

The trigger text is followed by instructions. The tutor should facilitate the discussion of these questions as needed. Students are asked to list key information regarding the patient, identify major problems and for each problem, make a list of how it may be caused (provide their hypotheses). Then they are asked to develop a mechanism to explain each hypothesis they have proposed and discuss factors that could contribute to the problem. This part is approximately 60 minutes and is completed by asking students about further information that might be obtained from history questions to help them to refine their hypothesis. Students should also explain their reasoning.

What is the rationale for using PBL? The PBL approach is based on cognitive psychology and the broad principles of adult education. This approach differs fundamentally from the traditional approach in which students acquire background knowledge of the basic sciences in the early years of the course and apply this knowledge to the diagnosis and management of clinical problems in the later years of their program. The traditional approach has been criticized for a number of reasons.[16,30,31] The major areas of criticism are: the traditional approach creates an artificial division between basic sciences and clinical practice, academic institutions focus on scientific research rather than on the competencies needed in practice, time is wasted in acquiring knowledge that is subsequently forgotten or found to be irrelevant in the future, application of knowledge acquired from basic sciences can be difficult and the acquisition and long-term retention of information that has no apparent relevance can be boring and of

Table 1 - Available definitions of problem based learning.

(1) "The learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem solving or reasoning skills, as well as for the search for a study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be solved."[1]
(2) "The term applies to any method that achieves 4 important objectives in medical education: the structuring of knowledge for use in the clinical contexts, the development of an effective clinical reasoning process, the development of self-directed learning skills and increasing motivation for learning".[19]
(3) "It is crucial that the problem raise compelling issues for new learning and that students have an opportunity to become actively involved in the discussion of these issues, with appropriate feedback and corrective assistance from faculty members".[21]
(4) "An nonstructural method characterized by the use of patient problems as a context for students to learn problem-solving skills and acquire knowledge about the basic and clinical sciences".[22]
(5) "An approach to learning and instruction in which students tackle problems in small groups under the supervision of a tutor".[17]
(6) "A method of learning or teaching that emphasises the study of clinical cases, either real or hypothetical; small discussion groups; collaborative independent study; hypothetical-deductive reasoning and a style of faculty direction that concentrates on group process rather than imparting information".[23]

Table 2 - Clinical reasoning: steps in problem based learning process.

Tutorial 1:
* Students working in small groups (8-10 students), clarify the cues in the trigger text. The trigger may also be a series of images, 2-3 minute video or a cartoon.
* Students define problems in the trigger (Problem formulation) and retrieve own knowledge relating to the identified problems.
* Students generate a list of hypotheses for each problem.
* Students develop methcanisms to explain each of their hypotheses. They then develop an enquiry strategy based on their hypotheses.
* Students read further information provided with the problem of the week (eg. medical history).
* Students use the new information to support or exclude each of their hypotheses.
* Students identify areas of gaps in existing knowledge. They may negotiate, delegate, and refine their learning issues throughout tutorial 1.
Between tutorial 1 and 2:
* Students work independently and look for information/answers to each of the learning issues identified by the group in tutorial 1. Students may use resources such as textbooks, journal articles, web sites, computer aided programs (CAL) in this process.
Tutorial 2:
* Students group reconvenes, about 3 days after tutorial 1, to discuss their own learning issues. They discuss knowledge acquired and link the new information to issues raised in the problem.
* Students discuss laboratory investigations that might help them to confirm their final hypothesis.
* They may discuss any other issues in the problem (eg. cultural issues, psychosocial problems or ethical issues).
* Students synthesise and summarise evidence collected from the trigger, medical history, and physical examination and investigation results to support their final clinical impression.
* Students discuss with their tutor, group performance and feed back on group dynamics and suggestions to improve group performance.

limited value. In addition to these limitations in traditional approach, a number of factors have influenced the increased adoption of PBL:- a need for professionals to be more able to fulfill the needs of the community;[32] information explosion in many areas of professional knowledge and the introduction of informatics in medical education;[25,33] a need for professionals to be able to adopt challenges in biology as well as social origins of health and disease.[34] The need to foster the development of practical skills needed by professionals and life long learning.[2,14,19] The need for multi-professional education and effective communication in health care systems.[35] The growing interest in learning and teaching at the tertiary level and the fact that professional practice is constantly changing and involves complexity, uncertainty, instability and values conflicts has further influenced the dissemination of PBL in medical education.[36] Many international meetings and conferences have recommended new guidelines for medical education.[37-39] These meetings raised the issue that learning should be as similar as possible to professional activities and the need for the introduction of integrated, problem-based learning or problem-solving, and multi-professional.[37-40] The rapid development of science and the changes in the health care systems requires new tasks and innovations in professional health that meets community health needs, promotion of health, socio-cultural differences, ability to solve problems and to work in teams and use managerial skills. Problem-based learning and multi-professional training provides an ideal strategy to close the gap between education and practice. They focus on learning instead of teaching and are able to create an attitude that will facilitate the process of learning throughout life.[6,41]

What are the educational objectives of PBL? The need for change to improve medical education raises several key features regarding the acquisition of knowledge, use and application of knowledge, interpretation of data and development of lifelong learning skills. According to Barrows, the educational objectives of PBL fulfill these key features.[42] The educational objectives of PBL can be summarized as follows: (1) to acquire a knowledge base that should be better retained, useable in clinical context, extended by future self-directed study and integrated from the many disciplines relevant to medicine; (2) to develop clinical reasoning (problem solving) skills characteristic of the expert clinician; (3) to develop self-directed learning skills; (4) to encourage sensitivity to all patients' needs both medical and psycho-social; (5) to provide a student-centered learning method that is motivating for the students, perceived as relevant to a career in medicine, capable of being individualized to the needs of each students, and (6) to encourage independent critical thinking skills.

The major objectives of PBL are discussed in the next section. I have also included currently available evidence regarding the extent to which PBL promotes these objectives when compared with more conventional approaches in education.

Achieving integration. Problem-based learning embodies critical thinking in education. In doing so it opens the curriculum, not by assuming that a move must be made from disciplinary to interdisciplinary, but by considering whatever is needed in tracking problems.[16,43] Problem-based learning programs seek understanding of appropriate depth in response to the problem in question. In the case of education this is likely to involve not only philosophical and sociologic issues but also psychological, historical and economic considerations in an interactive way.[15] Schmidt and Boshuizen found that without integration of basic science knowledge, the basic science knowledge cannot be applied flexibly in clinical settings.[44] Recently, it has been shown that students trained within the context of a PBL curriculum displayed better diagnostic performance than students trained within a conventional curriculum.[45] The integration of basic and clinical sciences proposed to cause this effect.

Achieving cognitive objectives. Several studies have demonstrated that PBL students are more likely to use the hypothesis-driven reasoning strategies on a novel problem than the non-PBL students. In addition, the PBL students were more able to provide coherent explanations to problems compared to non-PBL students and were more likely to include scientific concepts in their reasoning.[46-47] These 2 studies focused on a cognitive prospective drawn from research on PBL students and provided some evidence that PBL at least contributes to the making of better doctors. Recently, students in full-time PBL, elective PBL and full-time traditional curricula at 2 schools were compared on a series of patho-physiological explanation tasks over the course of the first year of medical school.[48] The students' ability to solve problems was considered from several viewpoints such as accuracy, coherence and comprehensiveness of explanation, reasoning strategies and use of science concepts. The data from this study clearly shows that PBL students generate explanations that are more accurate, coherent and comprehensive than non-PBL students. They were able to transfer the reasoning strategies that they are taught and are more likely to use science concepts in their explanations. This effect was stronger for the full-time PBL students. The authors concluded that by promoting the use of hypothesis-driven reasoning strategies, PBL might accelerate this development as students engage knowledge that will eventually become encapsulated

under their hypotheses. Furthermore, PBL context appears to incorporate all the conditions that facilitate deep learning[49-52] whereas the experience of conventional professional education seems to encourage a superficial level of learning.[53,54]

Promoting small-group learning. The small-group format of PBL is invaluable in the development of negotiation, communication and collaborative skills.[14,55] Small-group work is better than a lecture for higher order activities, e.g., analysis, evaluation and synthesis. This may reflect increased motivation in small-groups. Active preparation, with face-to-face contact may ensure that a member seeks to understand at a deeper level. Group discussion activates previously acquired understanding, helping identify any deficits and facilitating new comprehensions.[1,3] Other benefits of small-group learning include, promotion of an adult style of learning and development of collaborative learning and other transferable skills.[56] According to Hare, the key attitudes which aid group functioning are positive attitudes to the group, positive attitudes towards interaction, readiness to be creative and readiness to be critical at the right time and in the right way.[57] This view regarding developing positive attitudes to facilitate co-operative PBL team work has been recently supported.[58] Among the important positive attitudes towards the group are: join the group without deciding ahead of time that the experience will be unpleasant, be committed to the group process and consensus and have a feeling of responsibility to expend time and energy for the group.[58]

Promoting self-directed learning. Self-directed learning is an adult learning strategy. It is information seeking behavior in response to identified learning needs. This leads to targeted use by the learner of a variety of learning resources to overcome deficiencies in knowledge, skills or professional development. Effective self-directed learning requires the development of self-assessment skills, critical appraisal skills and effective time management. Studies have shown that PBL students have different study patterns than those of conventional curriculum students.[59] Vernon and Black conducted 5 separate meta-analyses on 35 studies representing 19 institutions.[23] They found that the PBL students used more journal articles, electronic searches, books, and self-selected resources and felt more competent in information-seeking skills. Newble and Clarke found 3rd and 4th year PBL students were more likely to study for meaning than conventional students.[50] Blumberg and Michael used a variety of measures, including library circulation data, to show that students in a problem-based track borrowed more material during the course than did students from the conventional curriculum (67 books/student/year versus 43) and that this difference was amplified in the clerkship (40 for students from the problem-based curriculum versus 11 for those on the conventional track).[60] Shin et al have shown a higher score on a written test on hypertension for graduates of a problem-based program 10 years after graduation; however, this data was not corrected for possible base-line differences in knowledge or for differential retention of knowledge.[61] Norman and Schmidt reviewed the experimental evidence supporting differences in student's learning that can be attributed to PBL.[62] They found that PBL enhances intrinsic interest in the content to be mastered, and it appears to enhance and maintain self-directed learning skills.

Promoting teamwork. Working in groups provides mutual support, laying the foundations for future behavior and strategies adopted with professional members of the team.[8] Transferable skills (e.g., leadership, teamwork, organizations, giving support, prioritizing and setting tasks, problem solving, motivating climate and managing time) are seen as important attributes in health professionals. Such competencies are best fostered not by direct teaching to transmit information but by teaching to encourage specific kinds of cognitive activities. Students can observe the effect they have on other members of the group. These experiences may influence future behavior and strategies adopted with professional members of a team. Multi-professional aspects of health care require team working and PBL allows students to work effectively in small groups and develop teamwork, communicating skills and collaborative learning.[56] In PBL programs which emphasize the importance of early contact with patients and clinicians, students practiced communication skills from the first week of year one and were more able to explore the importance of role models in clinical education and the significance of teamwork in health care systems.[63]

In conclusion, PBL presents the most promising prospects for better medical education. Qualities ensured by PBL such as self directed learning, enhancement of cognitive learning and integration, teamwork, cooperative peer learning, development of reflective attitudes, critical evaluation and assessment, suggest a potential value of its implementation in medical education. However, some of these qualities still need full investigation to ensure the validity and long-term effectiveness of PBL to produce competent doctors for the new millennium.

Acknowledgment. I would like to thank Professor Richard Larkins, Dean of the Faculty of Medicine, Dentistry and Health Sciences, and Associate Professor Susan Elliott, Director of the FEU, Faculty of Medicine, Dentistry and Health Sciences, the University of Melbourne, Victoria, Australia for their valuable comments and input during the preparation of the manuscript.

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