Postgrad Med J 1996; 72: 535–538 © The Fellowship of Postgraduate Medicine, 1996

Techniques in medical education: problem-based learning

Series editor: Dr John G Bligh, Professor of Primary Care Education, Royal Liverpool University Hospital, Liverpool L69 3BX, UK

The advantages of problem-based curricula

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Summary

Problem-based curricula provide a learning environment in which competence is fostered not primarily by teaching to impart knowledge, but through encouraging an inquisitive style of learning. Preliminary discussion in small groups, contextual learning, integration of knowledge and an emphasis on patient problems, have several cognitive effects on student learning. These effects are increased retention of knowledge, enhancement of integration of basic science concepts into clinical problems, the development of self-directed learning skills, and the enhancement of students' intrinsic interest in the subject matter. In this paper a number of studies will be reviewed that provide empirical evidence for these premises.

Keywords: problem-based learning, education

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Acccepted 13 November 1995

The quality of medical education has attracted considerable interest during the last few years. This interest is especially concerned with the question of how education can be more relevant to the needs of today's society. The report of the Association of American Medical Colleges panel on the General Professional Education of the Physician (GPEP), *Physicians for the twenty-first century*, contains a number of recommendations to improve the general professional education of the physician and has stimulated broad discussion among medical schools.[1] The report states that emerging changes in today's society such as rapid advances in technology, changes in demographics, environmental factors and lifestyle may require a revision of the present system of education for the health professions. Education should be aimed at training students how to deal with problems in the future, preparing themselves to become active, independent learners and problem solvers, rather than more or less passive recipients of information. Basic science teaching and clinical education should be integrated whenever appropriate to promote their application to clinical problem solving. A worldwide change in education for health professions is needed such that education continues to contribute to the health status of the population and reaches groups that do not yet have access to care. The Edinburgh Declaration,[2] which stemmed from a conference organised in response to the discussion raised in the abovementioned report, suggests a number of ways along which the report's ideas can be translated into effective instructional programmes. Settings in which educational programmes are conducted should ensure continuity of learning throughout life.

Problem-based learning (PBL) is considered as an instructional approach that may solve some of the important problems of medical education such as the difficulties encountered by students to use the knowledge gained in a clinical setting, the lack of integration of the knowledge acquired in the different disciplines and the need for continuing education.[3]

PBL is an approach to learning and instruction in which students tackle problems in small groups under the supervision of a tutor. Most problems consist of a description of a set of phenomena or events that can be perceived in reality. These phenomena have to be explained by the tutorial group in terms of their underlying principles, mechanisms or processes. This approach can be considered a systematic attempt to apply findings of cognitive psychology to educational practice. These findings indicate that competence is fostered not primarily by teaching to impart knowledge, but through encouraging an inquisitive style of learning. This style of learning is assumed to foster increased retention of knowledge, while it may improve students' general problem-solving skills, enhance integration of basic science concepts into clinical problems, foster the development of self-directed learning skills, and strengthen students' intrinsic motivation. The evidence for these advantages claimed for problem-based curricula is reviewed in this paper.

Increased retention of knowledge

PBL students are assumed to be better able to learn and recall information through
- activation of prior knowledge
- elaboration on newly acquired knowledge
- contextual learning.

Preliminary discussions in small groups help students mobilise whatever knowledge is already available. Based on this prior knowledge, learners actively construct explanatory models, which in turn facilitate the processing and comprehension of new information. In addition, new information is better

understood if students are stimulated to elaborate on it. Elaboration can take several forms, such as discussion, note-taking or answering questions. These activities help students to construct rich cognitive models of the problems presented to them.[4] Both activation of prior knowledge and elaboration, facilitate student learning. Illustrative evidence for these claims comes from two experiments in which subjects were asked to discuss a problem and elaborate on possible explanations.[5,6] Subsequently, these subjects were required to study a problem-relevant text. The subjects who had discussed the problem recalled much more information from the text than the control group. These data suggest that problem analysis is indeed an effective procedure for activation and elaboration of knowledge, facilitating comprehension of relevant new information. A direct test of the long-term effect of PBL on recall is provided by a study of Tans and colleagues.[7] In this study the performances of physiotherapy students randomly assigned to either a problem-based or a lecture-based version of a course in muscle physiology were compared. A free-recall test of core knowledge taken after six months showed that students from the PBL group recalled up to five times more concepts than the control group. Norman and Schmidt,[8] reviewing the literature for empirical evidence supporting the theoretical advantages claimed for PBL, concluded that several studies consistently reported that PBL students retain knowledge much longer than students under conventional teaching conditions. The third reason why PBL students are assumed to be better able to learn and recall information, is that learning in context is considered to make information more accessible for later use. In PBL, new knowledge is acquired in the context of some professionally meaningful problem or situation. Situated knowledge is assumed to be more accessible, because the situational cues that activate the knowledge are stored within the same cognitive structures.[9,10] Thus, matching context facilitates recall.

General problem-solving skills

The ability to care for patients and solve their problems is considered by many educators to be the major objective of medical education. The acquisition of knowledge is, in this view, only useful to the extent that it facilitates medical problem-solving. An advantage claimed for PBL would be that it enhances students' general, content-free problem-solving skills. Exposure to real-life problems is assumed to foster clinical reasoning or problem-solving skills in students. The interaction with the problem is an opportunity to practice one's problem-solving skills. An important question is whether students following problem-based curricula are better problem-solvers than students following conventional curricula. There is weak evidence that students from problem-based curricula perform better on tasks related to clinical competence.[11] A general problem-solving skill that can be taught and learned in PBL is probably a fallacy since this skill appears to be content specific. Succesful solving of a particular problem does not predict success in solving a new problem within a domain. This phenomenon is labelled content specifity. In this respect, it is not surprising that, up to now, there is no evidence that PBL is able to enhance students' problem-solving skills, although there may be some kinds of discipline-specific strategies for some classes of problems that have not yet been identified. To date, there is no evidence that problem-based or other curricula are able to enhance students' problem-solving skills independent of their acquisition of knowledge.[8]

Integration of basic science concepts into clinical problems

Problem-based curricula, while focusing on the application of 'old' knowledge in new situations, are said to encourage the integration of knowledge from different domains (eg, biomedical and clinical knowledge). Not surprisingly, an advantage claimed for PBL is that students may be better able to integrate basic science knowledge into the solutions of clinical problems.[12] Since all the relevant concepts, from anatomy to epidemiology, are learned in the context of a clinical problem, they should be better integrated when a similar problem is encountered in a clinical setting. Patel and colleagues[13] asked students following a conventional and a problem-based curriculum to solve a clinical problem and then integrate three passages of relevant basic science knowledge into their explanations of the problem. The PBL students advanced many more causal explanations than did those following the conventional curriculum. They were able to integrate basic science and clinical knowledge at all levels, while the students from the conventional curriculum in the preclinical years did not adequately deal with the clinical aspects of the problem. However, although

Problem-based learning

- students are better able to learn and recall information due to activation of prior knowledge, elaboration, and contextual learning
- students are better able to integrate basic science knowledge into the solution of clinical problems
- students are better self-directed learners
- PBL enhances students' intrinsic interest in the subject matter
- neither problem-based nor other curricula are able to enhance students' problem-solving skills independent of their acquisition of knowledge

PBL students tend to produce a larger number of causal explanations, many were incorrect. In a study by Hmelo,[14] diagnostic performances were compared between medical students following a PBL curriculum and those following a conventional one. At three points during the course of a year, these students were requested to produce a diagnosis and explain the underlying pathophysiology of two cases. The accuracy of diagnostic hypotheses produced by PBL students increased over time, whereas the students from the conventional track did not show this increase. In addition, the PBL students showed more coherence in their pathophysiological explanations. In both the Patel [13] and the Hmelo studies[14], the PBL students produced more causal explanations. In Hmelo's study, the PBL students produced better causal pathophysiological explanations, whereas in the Patel study, the PBL students did not perform as well as the students from the conventional track. In a recently completed study conducted by Schmidt and colleagues,[15] diagnostic performances of students educated in either a problem-based, an integrated, and a conventional curriculum were compared. The integrated curriculum is characterised by small-group teaching with more structured elements (eg, lectures and laboratory exercises) than the PBL curriculum. Students in the three groups were requested to provide differential diagnoses for 30 cases. Students following the PBL or integrated curricula displayed better diagnostic performances than students following a conventional curriculum. The integration between basic and clinical sciences and an emphasis on patient problems is assumed to cause this effect. In conclusion, students in a problem-based curriculum integrate their knowledge of basic science concepts better into clinical problems than students in a conventional curriculum.

Self-directed learning skills

In PBL students 'learn to learn', so that they can make their learning relevant to their own educational needs.[3] By analysing and discussing problems, students learn how to deal with problems in the future, preparing themselves to become independent, self-directed, lifelong learners. In addition, Barrows and Tamblyn[3] claim that students learn to see gaps in their own knowledge and to evaluate their own strengths and weaknesses. In other words, students learn to reflect upon and control their own learning and develop self-regulatory skills.[16] Moreover, because students conduct literature searches themselves, they learn to find the necessary materials independently and acquire the ability to continue their education after they graduate.[3] In other words, the emphasis on self-directed learning would promote an inquisitive learning style conducive to lifelong learning. That PBL is indeed successful in enhancing self-directed learning skills which are maintained is indirectly suggested in a study by Blumberg and Michael.[17] Data from library circulation statistics showed that PBL students borrowed more material than students from a conventional curriculum during both pre-clinical and clerkship years. This study demonstrates that PBL does have a large and potentially long-lasting impact on self-directed learning skills.

Intrinsic interest in subject matter

Another advantage of PBL claimed by its advocates is that it enhances intrinsic interest in subject matter. According to Barrows and Tamblyn,[3] the student-centered learning approach increases motivation because students themselves define the learning issues and decide for themselves what is relevant for their learning. In addition, problem discussion would enhance intrinsic interest in subject matter because it involves the learners more actively in the issues at hand.[18] The discussion of a problem is supposed to engage the students in the subject, which influences their intrinsic interest. In an experiment, students discussed a problem and tried to explain the phenomena described in this problem in terms of their underlying mechanisms. At the end of this problem-discussion session, experimental subjects were more interested in studying the relevant literature, and more interested to attend a lecture on this issue than control subjects.[18] Thus, PBL enhances students' intrinsic interest in the subject matter.

Conclusions

PBL can be considered a systematic attempt to apply findings of cognitive psychology to educational practice. Studies in understanding learning and cognition indicate that competence is fostered not primarily by teaching to deliver knowledge, but through teaching to engender specific kinds of cognitive

activity.[16] PBL is assumed to be an instructional approach reflecting these scientific concepts of the conditions of human cognition and learning. A number of studies provide empirical support for the advantages claimed for PBL. PBL students are indeed better able to learn and recall information and to integrate basic science knowledge into the solutions of clinical problems. In addition, PBL does have a large and potentially long-lasting impact on self-directed learning skills and on students' intrinsic interest in the subject matter.

There is, however, a need for further experimental studies on whether students actually construct new ideas while discussing a problem, on the role of misconceptions expressed or developed in the tutorial group, and on whether discussing a particular problem subsequently helps students to solve a similar problem. In addition, it would be interesting to know to what extent different curricular features influence student learning in PBL. For example, what factors of the tutorial group discussion influence what students will do during subsequent individual study? What is the influence of a low or highly structured problem, and is it possible to deduce principles for problem design? These questions remain to be answered by future studies.

1 Association of American Medical Colleges. *Physicians for the twenty-first century*. Report on the General Professional Education of the Physician. Washington, DC, 1984.
2 World Federation for Medical Education. The Edinburgh Declaration. *Ann Community-oriented Educ* 1989; **2**: 111–3.
3 Barrows HS, Tamblyn RM. *Problem-based learning: an approach to medical education*. New York: Springer, 1980.
4 Schmidt HG. Foundations of problem-based learning: some explanatory notes. *Med Educ* 1993; **27**: 422–32.
5 Schmidt HG, De Volder ML, De Grave WS, Moust JHC, Patel VL. Explanatory models in the processing of science text: the role of prior knowledge activation through small-group discussion. *J Educ Psychol* 1989; **4**: 610–9.
6 Schmidt HG. Activatie van voorkennis en tekstverwerking. [Activation of prior knowledge and text processing]. *Ned Tijdschr Psychol* 1984; **39**: 335–47.
7 Tans RW, Schmidt HG, Schade-Hoogeveen BEJ, Gijselaers WH. Sturing van het onderwijsleerproces door middel van problemen: een veldexperiment. [Directing the learning process by means of problems: a field experiment]. *Tijdschr Onderwijsres* 1986; **1**: 35–46.
8 Norman GR, Schmidt HG. The psychological basis of problem-based learning: a review of the evidence. *Acad Med* 1992; **67**: 557–65.
9 Brown JS, Collins A, Duguid P. Situated cognition and the culture of learning. *Educ Res* 1989; **18**: 32–42.
10 Tulving E, Thomson DM. Encoding specificity and retrieval processes in episodic memory. *Psychol Rev* 1973; **5**: 352–73.
11 Schmidt HG, Dauphinee WD, Patel VL. Comparing the effects of problem-based and conventional curricula in an international sample. *J Med Educ* 1987; **62**: 305–15.
12 Barrows HS. *How to design a problem-based curriculum for the pre-clinical years*. New York: Springer, 1985.
13 Patel VL, Groen GJ, Norman GR. Two modes of thought: a comparison of conventional and problem-based curricula. *Acad Med* 1991; **66**: 380–9.
14 Hmelo CE. *Development of independent learning and thinking: a study of medical problem solving and problem-based learning*. Unpublished doctoral dissertation, Nashville, Tennessee: Vanderbilt University, 1994.
15 Schmidt HG, Machiels-Bongaerts M, Hermans H, Ten Cate O, Venekamp R, Boshuizen H. The development of diagnostic competence: a comparison between a problem-based, an integrated, and a conventional medical curriculum. *Acad Med* 1996; (in press).
16 Glaser R. The maturing of the relationship between the science of learning and cognition and educational practice. *Learning and Instruction* 1991; **1**: 129–44.
17 Blumberg P, Michael JA. Development of self-directed learning behaviors in a partially teacher-directed problem-based learning curriculum. *Teaching and Learning in Medicine* 1992; **1**: 3–8.
18 Schmidt HG. Intrinsieke motivatie en studieprestaties: enkele verkennende onderzoekingen. [Intrinsic motivation and achievement: some investigations]. *Pedagogische Studieën* 1983; **60**: 385–95.