Undergraduate medical education: comparison of problem-based learning and conventional teaching

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Objective. To review the literature on studies comparing all aspects of problem-based learning with the conventional mode of teaching.
Data sources. *Medline* literature search (1980 through 1999) and the references cited in retrieved articles.
Data selection. Studies and meta-analyses that compared the newer problem-based learning curriculum and the conventional lecture-based mode of teaching undergraduate medical students. Areas of comparison included the academic process; programme evaluation; academic achievement; graduates' performance, specialty choices, and practice characteristics; and the attitude of students and teachers towards the programmes.
Data extraction. Data were extracted independently by multiple authors.
Data synthesis. Students of the problem-based learning curriculum found learning to be "more stimulating and more humane" and "engaging, difficult, and useful", whereas students of the conventional curriculum found learning to be "non-relevant, passive, and boring". Students who used the problem-based learning method showed better interpersonal skills and psychosocial knowledge, as well as a better attitude towards patients. Students using the conventional model, however, performed better in basic science examinations. Teachers tended to enjoy teaching the newer curriculum. Although the two curricula encourage different ways of learning, there is no convincing evidence of improved learning using the problem-based learning curriculum.
Conclusion. A combination of both the conventional and newer curricula may provide the most effective training for undergraduate medical students.

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Key words: Attitudes of health personnel; Curriculum; Education, medical, undergraduate; Evaluation studies; Problem solving; Teaching/methods

Introduction

There is growing concern among medical educators that conventional modes of teaching medical students (lecture-based curricula) neither encourage the right qualities in students nor imparts a life-long respect for learning.[1] Fundamental reforms in undergraduate medical education have been advocated for 100 years. In 1899, Sir William Osler[2] realised that the complexity of medicine had already progressed beyond the ability of the teachers to teach everything that students would need to know. Osler recommended abolishing the lecture method of instruction and allowing students more time to study. He also emphasised the important role of teachers in helping students to observe and reason. In 1932, the Commission on Medical Education of the Association of American Colleges[3] stated that medical education should develop sound habits as well as methods of independent study and thought, which will equip the students to continue their self-education through life. This can be brought about only by freeing medical education from some of its present rigidity and uniformity, by reducing classroom overcrowding, and by adapting medical education to more closely meet the educational needs of students.

Undergraduate medical education, as with any other educational programme, needs ongoing improvements to meet the changing demands of medical practice in the 21st century. Although the complexities of medical care have increased dramatically over the last century, the methods of teaching medicine have changed little. Teachers need to learn about the latest techniques and theories of both adult and medical

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education. Medical education should be given the same emphasis as research and patient care.

There has recently been widespread interest in the problem-based learning curriculum (PBLC). Since its adoption at McMaster University, Canada, in 1969,[4] the PBLC has grown in popularity and spread to many parts of the world, including Hong Kong. Despite this spread, there is continuing confusion about what the PBLC is and whether it can effectively replace the conventional curriculum.

The problem-based learning curriculum

In a student-centered problem-based curriculum, students learn by actively solving problems rather than by passively absorbing information. The PBLC uses a problem as the starting point for student learning.[5] While the knowledge imparted by a PBLC should be comparable to that of lecture-based curriculum, the PBLC goes beyond the latter in three important ways:

(1) A PBLC integrates basic science materials into a single programme. Facts that make up basic medical sciences are learned concurrently and always in the context of a particular health problem, because they are integrated into the same programme;
(2) Students must actively participate in their own education, with the emphasis being on learning; and
(3) In addition to biomedical training, students practice skills that will encourage them to become self-directed learners for the rest of their lives.

The key features of the PBLC at McMaster University are to analyse health care problems as the main method of acquiring and applying knowledge; to develop life-long learning skills; and to use small-group tutorials (six students) with a faculty tutor in each group.[2] An important aspect of the PBLC is teaching basic sciences in the context of a clinical problem, whether real or hypothetical. This serves two goals: to make knowledge more relevant and retrievable, and to foster the development of specific reasoning.[6]

The conventional curriculum

Conventional teaching separates the basic science segment from the clinical segment. In the conventional curriculum, teaching is tutor-centred and comprises large group lectures, tutorials, structured laboratory experience, and periodic tests of achievement. Students passively absorb information rather than actively acquire knowledge. The conventional curriculum is characterised by a 1- to 2- year basic science segment comprising formal courses drawn from various basic science disciplines. This is followed by clerkships in the clinical years of study. Educational research indicates that this format of teaching is frequently unstructured, the acquisition of skills is left largely to chance and is subject to little quality control, students are inadequately monitored, and feedback is seldom given.[7]

Several studies have compared the PBLC with conventional teaching. The areas of comparison have included the academic process; programme evaluation; academic achievement; graduates' performance, specialty choices, and practice characteristics; and faculty members' satisfaction.[8,9] Some studies have also compared the cost of teaching the PBLC with traditional teaching.[10]

The academic process and programme evaluation

Students in problem-based learning programmes place more emphasis on meaning (understanding) than reproduction (rote learning and memory); the opposite pattern prevails among students in traditional programmes.[8,9] Students using the PBLC also place more emphasis on journals and on-line databases as sources of information; make greater use of the library; make greater use of self-selected reading materials, as opposed to those selected by the teaching faculty; and more frequently feel competent in information-seeking skills.[10]

Moore et al[11] found that PBLC students who were enrolled in 1989 and 1990 at Harvard Medical School, United States, learned in a more reflective way, memorised less than their peers, and preferred active learning. The PBLC students also reported less 'cramming' before examinations; better retention of knowledge in the months afterwards; and, because the examination result was a pass or fail rather than a grade, feeling less stressed. In addition, they reported significantly greater autonomy, more innovation and involvement, and similar work pressures when compared with matched controls after 2 years. The PBLC students also felt more sure of themselves in handling uncertainty and were more likely to describe their preclinical years as being "engaging, difficult, and useful". In contrast, students following the conventional curriculum were more likely to use the key words "non-relevant, passive, and boring" to describe their preclinical experience.[11-13]

Students of the PBLC tend to use a more in-depth approach of learning than do students of the conventional curriculum.[14] An in-depth approach is encouraged by an interest in the subject matter and/or by its vocational relevance, whereas students who use a 'surface' approach are predominantly motivated by a concern to complete the course or by a fear of failure. They intend to fulfill the assessment requirements by the reproduction of factual materials.[14]

A study from McGill University, Canada, has shown that students of the new and conventional types of curricula exhibit distinctly different modes of reasoning.[15] When asked to give diagnostic explanations of a clinical case, PBLC students displayed a 'backward-directed' hypothetico-deductive mode of reasoning, whereas students of the conventional curriculum displayed a more 'forward-directed' method of reasoning. While the PBLC students gave extensive elaboration and cited relevant biomedical information in their answers, they also tended to generate errors. Nevertheless, PBLC beginners were able to give more coherent answers by using both clinical and basic science inferences, whereas their counterparts in the conventional group used basic science inferences to link haphazardly a few cues from the clinical context. Intermediate students of the PBLC generated a number of inferences based on basic science information, rather than on clinical examination, whereas the balance was reversed for the students in the conventional group.[15]

Students' attitudes

Studies have shown that students of the PBLC have a more positive attitude towards their curriculum than do students in a conventional class.[16-20] Kaufman and Mann[16] found that PBLC students had a more positive attitude towards teachers and their ability to arouse student curiosity. These results indicate a high level of enthusiasm among PBLC students and teachers. The PBLC allows students to identify their own learning issues and thereby substantially guide the tutorial process, which perhaps explains why PBLC students are more likely to find their learning environment more democratic than do students receiving conventional teaching.[16] Students using the PBLC have a greater intrinsic interest in learning—by solving problems, students learn new concepts—and, although the new format may initially reduce the amount that students learn, subsequent retention is increased.[17,18] The PBLC also has a psychological effect on students and teaching staff: more students reported that they found the learning environment "more stimulating and more humane" than did graduates of conventional schools.[17,18] With undergraduate medical education currently carrying a health warning because of the stress and anxiety caused to students and young graduates, any educational process that promotes enjoyment of learning without loss of basic knowledge and skills must be a good thing.[19,20]

At Harvard University, interpersonal skills, psychosocial knowledge and attitudes towards patients were found to be better in the PBLC ('new pathway') group.[11-13] Conventional curriculum students were more positive than their PBLC counterparts about student interaction in class, whereas PBLC students tended to form several factions within the class. The intensity of the small-group process may account for PBLC students becoming acquainted at a deeper level more quickly than in the conventional, lecture-based curriculum.[11-13] In contrast, Dolmas[21] found no difference between the two curricula in students' attitudes towards social issues in medicine.

Academic achievement

Performance in basic science examinations

Participants of the 1989 Macy Conference on the Evaluation of Innovative Curricula concluded that they would expect National Board of Medical Examination Part I (NBME I) scores to be lower for students in the innovative curricula than for students in conventional curricula.[22] Mennin et al[23] have reported that a more teacher-centred and structured conventional curriculum better prepares students for the NBME I. Similar findings have been reported in a meta-analysis conducted by Vernon and Blake.[24] Farquhar et al[25] have observed no significant differences in the total test scores among students of the two curricula, whereas students of the PBLC at the Mercer University School of Medicine, United States, did better in the NBME I.[26] The general perception is that PBLC students do not perform as well as conventional students in basic science examinations.

Clinical competence

Three general types of data relevant to clinical functioning have been used to evaluate PBLC: ratings and tests of clinical performance; tests of clinical knowledge (represented by the NBME Part II examination and the Federal Licensing Examination); and the 'humanism' variables studied in the evaluation of Harvard Medical School's PBLC students.[11] Most reports show a slight but non-significant trend in favour of PBLC students in clinical science performance.[11,23,24,26]

First choice of residency

One significant measure of success of a curriculum is the extent to which its graduates obtain their first choice of residency. Seventy-nine percent of McMaster University medical graduates received their first choice residency positions in 1989, compared with 58.9% for all Canadian graduates.[4] Ninety percent of graduates of the Mercer University School of Medicine received their first choice residency positions, with 71% doing so during the 7-year operation of the school's PBLC curriculum.[26]

Graduates' performance

Studies that compare the preparations of PBLC graduates with those of their peers in the conventional curriculum show no evidence to suggest that PBLC graduates perceive themselves to be disadvantaged.[27,28] Eighty-nine percent of McMaster University medical graduates of the PBLC regarded themselves to be equally or better prepared than their peers at independent learning, problem solving, self-evaluation, data-gathering, behavioural sciences, and dealing with social and emotional problems of patients. Of the supervisors, 62.5% described PBLC graduates as performing better or much better than first-year postgraduate fellow trainees.[27] Students of the PBLC have tended to rate themselves lower in terms of their basic science preparation.[27] In contrast, students of the conventional curriculum have tended to rate their training more positively in the areas of clinical medicine and biomedical science.[28]

Santos-Gomez et al[29] have compared the performances of 130 PBLC graduates and 130 graduates of a parallel, conventional curriculum at the University of New Mexico School of Medicine, United States. Graduates from the PBLC group received superior ratings than did graduates from the conventional group in the areas of health care costs, communication with patients, and patient education. Nurses gave a higher evaluation in knowledge to residents from the conventional curriculum. Data from Australia[30] show that graduates from the PBLC were rated significantly better than their peers, with respect to their interpersonal relationships, reliability, and self-directed learning.

Specialty choices and practice characteristics

In general, it seems that the PBLC tends to produce a higher proportion of graduates who choose careers in family medicine,[11] and some schools such as that at McMaster University produce graduates who pursue careers in family medicine in academic environments.[4] Graduates of the PBLC are less likely to locate to rural areas or be in solo practice than are their conventional counterparts.[31]

Faculty members' satisfaction

In a faculty survey of the McMaster University medical curriculum, PBLC was the most frequently cited strength.[32] In a survey of Dutch medical schools, the PBLC faculty rated their curriculum higher in teaching clinical reasoning, humanistic qualities, and preventive care than did the conventional faculty.[28] The latter, however, rated their schools higher in the teaching of clinical medicine and biomedical sciences.[28]

When asked what type of curriculum teachers would prefer, 72% of the teachers at McMaster University chose the PBLC.[33] At the same university, 95% of a faculty that used the PBLC said they would serve as a PBLC tutor again after having had the experience.[34] Thirteen of 14 non-volunteer tutors in a PBLC course said the experience was more positive than they had expected. The most often cited benefit was student contact, by virtue of the small-group format.[35] These studies suggest that tutors find the PBLC provides a satisfying way to teach.

Much of the dissatisfaction with the conventional medical curriculum has come about as a result of the pronounced shift towards lectures. The lecture method has proven far from satisfactory as a principle mode of instruction. Lectures tend to vary widely in quality and they attract low attendances. Thus, educators who use conventional curricula are forced to emphasise a inadequate method of instruction.[36]

Costs of the problem-based learning curriculum

The two most costly components of medical education are infrastructure/equipment and faculty (teacher) time. Both problem-based learning and conventional curricula require approximately the same infrastructure/equipment, so the costs involved are essentially similar. Faculty time devoted to preparing examinations, attending meetings, and performing ancillary activities is also approximately equivalent in both types of programme, as is the time devoted to teaching laboratories. It becomes apparent that in comparing the cost of the two curricula, one really compares the cost of the small-group tutorial format to that of the lecture format.

Because the mission of all medical schools is to transform students into doctors, the most valid unit of cost comparison is 'faculty hours per year per graduate' (FHYG). The Mercer University School of Medicine compared a 42-student PBLC pathology programme with a conventional lecture course in which 130 students were enrolled. The PBLC programme 'cost' 13.9 to 20.9 FHYG (mean, 17.4 FHYG). The lecture component of the conventional curriculum 'cost' 3.25 to 6.25 FHYG (mean, 4.8 FHYG). It was estimated that PBLC costs less per student for classes containing fewer than 40 students, and that PBLC may be impractical for class sizes greater than 100.[36] For class sizes greater than 100, there are fairly serious concerns about the economic viability of PBLC, although costs can be reduced by increasing group sizes, decreasing the number of times the group meets per week, or using non-faculty teachers for some meetings.[36]

The problem-based learning curriculum in Hong Kong

The PBLC was introduced to Hong Kong by the Faculty of Medicine of The University of Hong Kong in September 1997. The Faculty is prospectively collecting data about the impact of the new curriculum on undergraduates and teachers. The general impression is that teacher-student relationships in the PBLC curriculum are far more interactive than they used to be in the old curriculum. In the conventional format, a lecture is prepared in isolation and delivered with very little personal interchange. In the PBLC format, preparation time is minimal and 50% to 75% of the teaching effort is spent in close informal contact with students (unpublished data, 1999).

Another benefit of the new curriculum is that students are more communicative, show more initiative, and are more positive about preclinical training. They adjust more readily to clinical clerkships, are more likely to ask questions, and seem to have superior independent learning and problem-solving skills (unpublished data, 1999). These trends are reassuring, considering that many teachers in the faculty had expressed initial reservations about Hong Kong students' ability to cope with the PBLC.

Conclusion

Compared with conventional students, PBLC students place more emphasis on meaning than on memorising, use journals and on-line databases as sources of information, use self-selected reading materials, feel more confident in information-seeking skills, use a more in-depth approach of learning, and employ a 'backward-directed' hypothetico-deductive mode of reasoning. They also show better interpersonal skills, psychosocial knowledge, and attitudes toward patients. While they do not perform as well in basic science examinations as their conventional counterparts, they perform as well if not better in clinical examinations. Centres that have adopted a PBLC approach have found improved student motivation and enjoyment, but there is no convincing evidence of improved learning per se. An intelligent combination of using both the traditional and PBLC approaches may provide the most effective training for undergraduate medical students.

References

1. Kasselbaum DE. Change in medical education: the courage and will to be different. Acad Med 1989;64:446-7.
2. Osler W. An introductory address on examinations, examiners, and examinees. Lancet 1913;ii:1047-50.
3. Rappleye WC. Medical education: final report of the Commission on Medical Education. New York: Association of Medical Colleges, Commission on Medical Education; 1932:173-4.
4. Neufeld VR, Woodward CA, MacLeod SM. The McMaster M.D. programme: a case study of renewal in medical education. Acad Med 1989;64:423-32.
5. Burrows HS, Tamlyn RN. Problem-based learning: an approach to medical education. New York: Springer; 1989.
6. Walton HJ, Mathews MB, editors. Essentials of problem-based learning. Med Educ 1989;23:542-58.
7. Folse R, DaRosa DA, Paiva RE, Birtch A. A multidisciplinary surgery clerkship: ten-year experience. Surgery 1986;99: 178-183.
8. Coles CR. Evaluating the effects curricula have on student learning: toward a more competent theory for medical education. In: Noonan ZM, Schmidt GH, Ezzat ES, editors. Innovation in medical education: an evaluation of its present status. New York: Springer; 1990;76-93.
9. Entwistle NJ, Ramsden P. Understanding student learning. London: Croom Helm; 1983.
10. Rankin JA. Problem-based medical education: effect on library use. Bull Med Libr Assoc 1992;80:36-43.
11. Moore GT, Block SD, Style CB, Mitchell R. The influence of the New Pathway curriculum on Harvard medical students. Acad Med 1994;69:983-9.
12. Tosteson DC, Adelstein SJ, Carver ST, editors. New pathways to medical education: learning to learn at Harvard Medical School. Cambridge (MA): Harvard University Press; 1994.
13. McManus C. New pathways to medical education: learning to learn at Harvard Medical School. BMJ 1995;311:67.
14. Newble DL, Clarke RM. The approaches to learning of students in a traditional medical school. Med Educ 1986;20: 267-73.
15. Patel VL, Groen GJ, Norman GR. Effects of conventional and problem-based medical curricula on problem solving. Acad Med 1991;66:380-9.
16. Kaufman DM, Mann KV. Comparing students' attitudes in

problem-based and conventional curricula. Acad Med 1996;71:1096-9.
17. Norman GR, Schmidt HG. The psychological basis of problem-based learning: a review of the evidence. Acad Med 1992;67:557-65.
18. Schmidt HG, Norman GR, Boshuizen HP. A cognitive perspective on medical expertise: theory and implications. Acad Med 1990;65:611-21.
19. Weatherall DJ, The inhumanity of medicine. BMJ 1994;308:1671-2.
20. Dowie R, Charlton B. The making of a doctor. Oxford: Oxford University Press; 1994.
21. Dolmas D. How students learn in problem-based curriculum. Maastricht: Universitaire Pers Maastricht; 1994.
22. Friedman CP, de Bliek R, Greer DS, et al. Charting the winds of change: evaluating innovative medical curricula. Acad Med 1990;65:8-14.
23. Mennin SP, Friedman M, Skipper B, Kalishman S, Snyder J. Performances on the NBME I, II and III by medical students in the problem-based learning and conventional tracks at the University of New Mexico. Acad Med 1993;68:616-24.
24. Vernon DT, Blake RB. Does problem-based learning work? A meta-analysis of evaluation research. Acad Med 1993;68: 550-63.
25. Farquhar LJ, Haf J, Kotable K. Effect of two preclinical curricula on NBME Part I examination performance. J Med Educ 1986;61:368-73.
26. Donner RS, Bickley H. Problem-based learning: an assessment of its feasibility and cost. Hum Pathol 1990;21:881-5.
27. Woodward CA, Ferrier RM. The content of the medical curriculum at McMaster University: graduates' evaluation of their preparations for post-graduate training. Med Educ 1983;17:54-60.
28. Post GJ, Drop MJ. Perceptions of the content of the medical curriculum at the Medical Faculty in Maastricht: a comparison with traditional curricula in the Netherlands. In: Noonan ZM, Schmidt HC, Ezzat RS, editors. Innovation in medical education: an evaluation of its present status. New York: Springer; 1990;64-75.
29. Santos-Gomez L, Kalishman S, Rezler A, Skipper B, Mennin SP. Residency performance of graduates from a problem-based and a conventional curriculum. Med Educ 1990;24:366-75.
30. Rolfe IE, Andrew JM, Pearson S, Hensley MJ, Gordon JJ. Clinical competence of interns. Programme Evaluation Committee. Med Educ 1995;29:225-30.
31. Tolani S. Continuing medical education and career choice among graduates from problem-based and traditional curricula. Med Edu 1991;25:414-27.
32. Woodward CA. Monitoring an innovation in medical education: the McMaster experience. In: Noonan ZM, Schmidt HG, Ezzat BS, editors. Innovation in medical education: an evaluation of its present status. New York, Springer; 1990;27-39.
33. McAuley RG, Woodward CW. Faculty perceptions of the McMaster M.D. Program. J Med Educ 1984;59:842-3.
34. Moore-West M, O'Donnel MJ. Program evaluation. In: Kaufman A, editor. Implementing problem-based medical education: lessons from successful innovation. New York: Springer; 1985;180-206.
35. Maxwell JA, Wilkerson L. A study of non-volunteer faculty in a problem-based curriculum. Acad Med 1990;65(9 Suppl): 13S-14S.
36. Albanese MA, Mitchell S. Problem-based learning: a review of literature on its outcomes and implementation of issues. Acad Med 1993;68:52-81.