

A Problem-Based Learning Pathway for Medical Students: Improving the Process Through Action Research

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Abstract

Introduction: Problem-based learning (PBL) is student-centred, self-directed and collaborative. In medical education it is based on clinical cases and is widely considered to facilitate the development of key professional competencies. Whilst PBL is extensively employed in medical schools worldwide, Lake Erie College of Osteopathic Medicine is one of very few schools that offer it to pre-clinical students as a major pathway of study. We have identified several problems associated with implementation of the programme and attempted to provide solutions with 3 new learning tools. In this study we use action research to evaluate the success of our strategy. **Methods:** We examined the students' perception of the effectiveness of case-based formative assessment, case-based "question and answer" workshops, and reviews of annotated examinations as learning tools, using a 5-point Likert scale questionnaire. **Results:** A majority of both first- and second-year students perceived all 3 learning tools to be helpful. In general, the most positive responses were received from second-year students. First-year students evaluated case-based formative assessments more positively when they were about to take examinations. **Conclusions:** Case-based formative assessments, case-based workshops and reviews of annotated examinations were perceived as helpful learning tools by both first- and second-year medical students in PBL learning pathways.

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Introduction

Problem-based learning (PBL) is a student-centred, self-directed, integrated and contextual mode of learning. It has been widely perceived by many to confer advantages in promoting critical thinking, retention of knowledge, independent learning and interpersonal skills. The introduction of the first PBL curriculum in medical education is commonly attributed to McMaster University almost 40 years ago¹ although some problem-based components of medical education had already been introduced elsewhere.²⁻⁴ Problem-based learning curricula were subsequently adopted at Maastricht in the Netherlands and Newcastle in Australia and thereafter the PBL approach soon spread worldwide. In 1979, the University of New Mexico Medical School became the first in the USA to offer a PBL pathway and, in 1982, Mercer University School of Medicine became the first to offer PBL as its sole curricular pathway.⁵ Currently some 70% of US medical schools employ PBL in the pre-clinical years, but fewer than 6% use it for more than half of their curriculum.⁶

The Problem-Based Learning Pathway at LECOM

Lake Erie College of Osteopathic Medicine (LECOM) offers 3 pre-clinical curriculum pathways – lecture-discussion, independent study and problem-based learning – in its Doctor of Osteopathic Medicine (DO) programme. In the USA, DOs are fully qualified physicians, who are licensed both to prescribe medication and to perform surgery. In the PBL pathway, 40 students currently matriculate each year at the Erie campus. Students in all 3 pathways follow a common didactic course in Anatomical Sciences, after which the PBL students study the basic sciences almost completely by PBL. This comprises about 70% of their total pre-clinical curriculum (Table 1). Groups of 8 students, each with a facilitator, meet 3 times per week, to study a sequence of more than 70 patient cases in paper presentation. The student groups select learning issues associated with each case, and these are used to generate examinations that are administered at intervals of about 6 weeks. Different examinations are produced for each student group, reflecting their different choices of learning issues.

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Table 1. Subjects Studied Through PBL Cases in the LECOM PBL Pathway

Gross Anatomy	Biochemistry	Internal Medicine
Embryology	Medical Genetics	Neuroscience
Histology	Immunology	Pathology
Behavioural science	Microbiology	Pharmacology Physiology

LECOM: Lake Erie College of Osteopathic Medicine; PBL: problem-based learning

The PBL Group Session

At the commencement of a PBL case study, all students in the group are given only the age, gender and chief complaint of the patient. In the initial discussions that follow, one student plays the role of patient and he/she alone is given details of the patient history. Another student plays the role of physician. This student interviews the patient to obtain the history, after which, in the sequence taught in Clinical Examination classes, he/she requests a verbal account, from the facilitator, of each aspect of the physical examination. The student group, by now, should have drawn up a range of differential diagnoses – although, before they gain experience, this may be merely a list of affected systems. They then proceed as a team, requesting various further data, such as laboratory tests, or diagnostic procedures. The appropriate information is progressively disclosed by the facilitator in response to these requests. This information may be in the form of tabulated data or, for example, a radiograph. Supplementary workshops on diagnostic procedures and their applications are provided at an early stage to facilitate this process.

Progression to the definitive diagnosis generally requires 2 to 3 group sessions.

The periods between sessions are used for independent study of relevant topics that have been identified by the students as ones that may further their understanding of the case. Thus new information will be brought to each new session, at the start of which one of the students will briefly present the patient as one would on hospital rounds. Every student gives a brief verbal evaluation of each session at its conclusion and, at the end of each case, each member of the group evaluates the performance and contribution of every other member. This group process is summarised in Figure 1.

For each case the student group starts with a range of differential diagnoses and reduces this to the final, definitive diagnosis. Through the course of this process, learning issues are produced by the students (Fig. 2). These represent areas of knowledge that were required in order to understand fully the patient case and to reach a diagnosis. They take the form of designated sections of basic and medical science texts that are a prerequisite for study, stipulated by the PBL

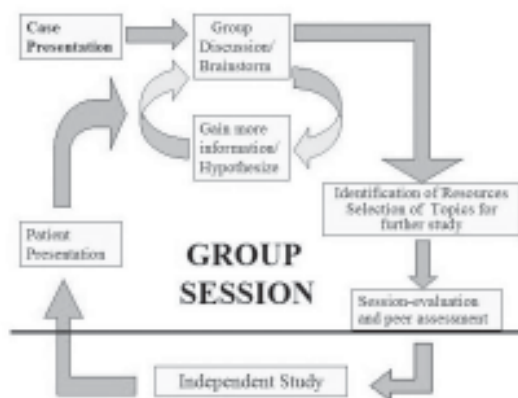


Fig. 1. The problem-based learning group session (Adapted from the Ohio State University College of Medicine and Public Health Problem-based Learning Pathway Student Handbook by John J Curry PhD).



Fig. 2. Generation of learning issues through the case study process.

management team. It is important to note that, whilst arriving at a diagnosis marks the end of each case study, the *primary purpose* of the PBL group sessions is not to reach a diagnosis *per se*, but to use the case as a vehicle for the generation of learning issues.

Student Assessment

Multiple-choice and matching examination questions, written for the most part in the style of the medical examining boards, are produced to test knowledge of material covered by the learning issues submitted. Generally 3 summative examinations are given per semester, each one testing information derived from the study of a set of 6 or 7 PBL patient cases. The examination score comprises the major component of the student grade. A small additional component emanates from facilitator and peer evaluations of the performance in each group. The student composition of PBL groups is changed after each set of cases.

Improving the PBL Process Through Action Research

Using an action research approach, we identified several problems related to the PBL process, applied a strategy to address them, and assessed the effectiveness of our strategy.

Problems Related to the PBL Process

In implementing our PBL programme we have identified several concerns, both emanating from the students' transition from a traditional, didactic, educational background, and inherent in the fundamental PBL process. Two of these are addressed here.

1. *Maintaining a study schedule.* How do we ensure that the students maintain an adequate work-rate in the absence of a traditional class schedule? This is particularly relevant in the US, where a large majority of the students entering the DO programme have been accustomed to being examined with greater frequency in their previous academic programmes. Consequently their established pattern of information acquisition may have been characterised by short-term memorisation immediately prior to examinations. A proportion of our students appeared to persist with this type of approach, attempting to reach the diagnoses for a group of cases in the fastest possible time, and then attempting to memorise the information related to all the cases in the group in the time period immediately preceding the examinations. In these circumstances, contrary to the fundamental tenets of PBL, learning is not undertaken in the context of each case.

2. *Acquisition of perspective.* In the absence of the guidance provided by a traditional didactic curriculum, how can we ensure that the students acquire a good perspective of the study material, recognising the important facts to know and concepts to understand? In the absence of the guidance that non-PBL students may receive in lectures, their learning strategies may be misdirected or inefficient. It is particularly important that this matter is adequately addressed in any PBL programme.

Addressing the Concerns

We addressed these concerns with the following 3 learning tools.

1. *Case-based formative assessment.* To motivate students to maintain effective study schedules, at the end of each case we require that the students, taking one learning issue each within a group, should each produce 3 multiple-choice questions, in the style of the medical boards. These questions are then pooled to produce an informal quiz of up to 24 questions, followed by student analysis of each question, before proceeding to the next case in the set. These quizzes do not contribute to student grades.

2. *Examination reviews.* To impart perspective of the study material, after each summative examination, the students reconvene in their PBL groups to study an annotated version of their examination, in which the provenance of each question is provided, along with reference to where the answer may be found in the relevant, required text.

3. *Case-based workshops.* To enrich the learning experience and enhance perspective, case-based workshops are provided on student request to cover material with which students may experience particular difficulty. These are conducted on a question and answer basis, in order to promote the PBL approach of student-driven enquiry.

Effectiveness of Strategy

A preliminary procedure has been initiated to measure the effectiveness of our strategy to address the concerns we identified. We have begun to assess student responses to each of our 3 learning tools through self-reporting, using a Likert psychometric scale.⁷

Methods

Both first- and second-year pre-clinical medical students in the problem-based learning class were asked to respond to several statements, relating to the effectiveness, as learning tools, of the case-based formative assessments (quizzes), annotated examination reviews and case-based workshops. The students were asked to indicate their level of agreement with the statements over the following scale: Strongly disagree (1) – disagree (2) – neutral (3) – agree (4) – strongly agree (5) (Table 2). The questionnaire also allowed for additional student comment.

Thirty-nine from a total of 40 first-year students, and 35 from a total of 37 second-year students completed the questionnaire.

Results and Discussion

Table 2 compares the responses of first- and second-year medical students to statements concerning the effectiveness of our 3 learning tools, on a 5-point Likert-type scale. Although this type of psychometric scale does not lend itself to rigorous statistical analysis, the mean response is presented as an indicator.

The second-year students were in stronger agreement than the first-year students with all statements, except that the case-based quizzes assisted them in maintaining a consistent work-rate through each set of cases. This exceptional response may reflect the second-year students' proximity to their medical board examinations which had, in itself, tended already to maximise their work ethic. Their more positive responses to all the other statements may perhaps be attributed to their more extensive experience.

The percentage of students who responded positively to each statement (responses 4 or 5) is also shown in Table 2. The most frequently selected response to each statement (mode) is presented in parentheses alongside each percentage value. With both of these metrics, a similar pattern is evident to that observed for the mean

Table 2. Comparison of First- and Second-year Student Responses to Statements Evaluating Learning Tools

Statement posed to students	Mean student response		% students responding 4 or 5	
	1 st year (n = 39)	2 nd year (n = 35)	1 st year (n = 39)	2 nd year (n = 35)
<i>The formative evaluations associated with each case</i>				
1. Facilitated my learning	3.74	4.06	67 (4)*	74 (4)
2. Helped me to maintain a consistent work-rate through each set of cases	3.85	3.57	69 (4)	57 (4,5)
3. Encouraged me to learn contextually (in the context of each case)	3.71	3.91	54 (4)	71 (4)
<i>The review of annotated examinations</i>				
1. Facilitated my learning	3.95	4.54	72 (4)	97 (5)
2. Enhanced my perspective of the material in the learning issues	3.74	4.57	64 (4)	97 (5)
3. Enhanced my understanding of the material in the learning issues	3.69	4.51	62 (4)	97 (5)
4. Enhanced my ability to analyse examination questions	4.08	4.63	62 (4)	97 (5)
5. Aided my preparation for subsequent examinations	3.67	4.49	69 (4)	94 (5)
6. The annotations were a valuable feature of the reviewed form of the examinations	4.31		87 (5)	
<i>The case-related workshops</i>				
1. Facilitated my learning	3.79	4.40	63 (4)	91 (5)
2. Enhanced my perspective of the material in the learning issues	3.68	4.31	63 (4)	94 (4)
3. Enhanced my understanding of the material in the learning issues	3.82	4.34	68 (4)	94 (4)
4. Aided my preparation for examinations	3.42	4.29	42 (3)	83 (5)

*The most frequently selected response (mode) to each statement is shown in parentheses

response values. The differences between the responses of first- and second-year students to the statements on examination reviews and on workshops become even more pronounced.

A closer analysis of the responses of first-year students proved somewhat revealing. Fifteen first-year students (Group A) responded immediately to the questionnaire when it was distributed, at the time that they were completing their last case study before studying for their final PBL examination. The remaining 24 students (Group B) did not respond until some time later, after they had studied for their examination. The data from these 2 groups of students is compared in Table 3. Clearly the students who completed the questionnaire after studying for their PBL examination showed a much greater appreciation of the value of the case-based formative assessments, but placed less value on the examination reviews. Many studies have demonstrated the importance of formative assessments such as these in improving academic performance.⁸

Fourteen of the second-year students commented positively on the case-based quizzes, although 5 of the 14 considered that their value diminished as they fell behind with the related learning. Four commented negatively. In contrast, only 6 first-year students commented positively on the case-based quizzes, whilst 8 commented negatively. Six first-year students disagreed (1 strongly) that the case-based formative assessments encouraged them to learn

contextually. Since it is difficult to construct a cogent argument against this statement, their response may simply be a reflection of their not wishing to participate in formative assessments. Indeed, it should be noted that similar considerations may be relevant in places throughout the data.

Five second-year students commented positively on the annotated examination reviews, and their comments on the value of the annotations led to the incorporation of a statement specifically addressing this in the first-year questionnaire. Twelve first-year students commented positively on the examination reviews, 6 of whom commented extremely positively. One commented that it was “one of the strongest learning tools I have ever encountered”.

Most comments related to the case-based workshops expressed individual views about specific workshops. The only comments that were entirely negative referred to the coverage of material that was not subsequently tested in examinations.

The high rate of response to the questionnaire, by both years of students, suggests that they considered the process to be worthwhile, which represents a positive outcome of this study. It is well established that motivational beliefs play an important role in the achievement of educational goals.⁹ The more positive responses of the second-year students, almost across the board, may reflect their sharper

Table 3. Comparison of Responses of 2 Sub-groups (A & B) of First-year Students to Statements Evaluating Learning Tools

Statement posed to students	Mean student response		% students responding 4 or 5	
	1 st year (A) (n = 15)	1 st year (B) (n = 24)	1 st year (A) (n = 15)	1 st year (B) (n = 24)
<i>The formative evaluations associated with each case</i>				
1. Facilitated my learning	3.13	4.13	40 (3,4)*	83 (4)
2. Helped me to maintain a consistent work-rate through each set of cases	3.33	4.17	47 (4)	83 (4)
3. Encouraged me to learn contextually (in the context of each case)	3.20	4.04	47 (4)	61 (4)
<i>The review of annotated examinations</i>				
1. Facilitated my learning	4.27	3.75	80 (5)	67 (4)
2. Enhanced my perspective of the material in the learning issues	4.20	3.46	87 (4)	50 (3,4)
3. Enhanced my understanding of the material in the learning issues	3.93	3.54	67 (4)	58 (4)
4. Enhanced my ability to analyse examination questions	4.20	4.00	80 (4,5)	83 (4)
5. Aided my preparation for subsequent examinations	4.13	3.58	73 (5)	67 (4)
6. The annotations were a valuable feature of the reviewed form of the examinations	4.47	4.21	93 (5)	83 (5)
<i>The case-related workshops</i>				
1. Facilitated my learning	3.93	3.70	60 (5)	65 (4)
2. Enhanced my perspective of the material in the learning issues	3.93	3.52	67 (4)	61 (4)
3. Enhanced my understanding of the material in the learning issues	4.07	3.65	73 (4)	65 (4)
4. Aided my preparation for examinations	3.73	3.22	47 (3)	39 (3)

A: Students completing questionnaire before studying for PBL summative examination

B: Students completing questionnaire while/after studying for PBL summative examination

* The most frequently selected response (mode) to each statement is shown in parentheses

focus on these goals as they approached their medical board examinations.

Conclusions

Our study demonstrated that a majority of both first and second-year medical students in our PBL class perceived case-based formative assessment, annotated examination reviews and case-based workshops to be helpful learning aids. First-year students were more positive about the value of case-based formative assessment as they approached their examinations. A higher percentage of second-year students were more positive about the value of annotated examination reviews and case-related workshops. The response of all the students suggested that they considered the action research process to be valuable.

The meaning of the data requires further investigation into how and why some students benefited more than others from the 3 learning tools. In order to understand better these differences in achievement motivation, follow-up focus groups will be interviewed.

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REFERENCES

- Neufeld VR, Barrows HS. The "McMaster Philosophy": an approach to medical education. *J Med Educ* 1974;49:1040-50.
- Harris JW, Horrigan DL, Ginther JR, Ham TH. Pilot study in teaching hematology with emphasis on self-education by the students. *J Med Educ* 1962;37:719-36.
- Ham TH. Medical education at Western Reserve University. A progress report for the sixteen years, 1946-1962. *N Engl J Med* 1962;267:868-74.
- Echt R, Chan SW. A new problem-oriented and student-centred curriculum at Michigan State University. *J Med Educ* 1977;52:681-3.
- Donner RS, Bickley, H. Problem-based learning in American medical education: an overview. *Bull Med Libr Assoc* 1993;81:294-8.
- Kinkade S. A snapshot of the status of problem-based learning in U.S. medical schools, 2003-04. *Acad Med* 2005;80:300-1.
- Likert A. A technique for measurement of attitudes. *Archives de Psychologie* 1932;6:173-7.
- Boston C. The concept of formative assessment. *Practical Assessment, Research & Evaluation*. 2002;8:9. Available at: <http://www.pareonline.net>. Accessed 21 May 2006.
- Beghetto RA. Toward a more complete picture of student learning: assessing students' motivational beliefs. *Practical Assessment, Research and Evaluation* 2004;9:15. Available at: <http://www.pareonline.net>. Accessed 21 May 2006.