Problem-Based Learning in Ophthalmology

A Pilot Program for Curricular Renewal

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Objectives: To gain experience with problem-based learning as a demonstration project in a medical school's curriculum renewal effort and determine if using a single facilitator to circulate among the small groups would yield positive results.

Design: We developed 16 cases around 4 ophthalmic problems that were used in 3-hour small-group sessions during the Introduction to Clinical Medicine semester of the second-year curriculum. A single faculty member facilitated the small groups of 4 students each that were created by self-division at each of 5 sessions.

Setting: A state-supported large Midwestern medical school.

Participants: All students (N = 75) enrolled in the Introduction to Clinical Medicine course prior to their standard introductory ophthalmology lectures.

Main Outcome Measures: A 5-item pretest, related to each of that day's clinical problems, was administered at the beginning and again at the end of the session as a posttest. A satisfaction questionnaire with Likert-type questions was also completed by the students at the close of the session.

Results: Knowledge scores showed statistically significant gains with a mean of 1.7 points. Student satisfaction was very positive—85% stated that they learned more than they would have in the traditional format and 93% agreed that they enjoyed the problem-based learning format.

Conclusions: A single facilitator successfully managed small groups of students in a modified problem-based learning format that produced significant knowledge gains and high student satisfaction. This positive experience was one of the factors that led to adoption of problem-based learning into the curriculum.


SINCE ITS INCEPTION at the end of the 1960s at McMaster University, Hamilton, Ontario, problem-based learning (PBL) has evolved into one of, if not the most, widely considered curricular innovations in medical education. It has been implemented as full curricula and as individual courses. Despite its wide acceptance, there is some concern that the cost of PBL may burden the resources of some institutions, especially those with class sizes exceeding 100. A key factor affecting the cost of PBL is the need for a facilitator for each small group of students.

The purpose of our study is to report on a pilot project intended to serve as a demonstration of PBL as part of a curriculum renewal effort at a large Midwestern medical school. The curriculum in its present form was established in the early 1970s, with traditional didactic learning for the basic sciences and introduction to clinical medicine followed by 2 years of clinical rotations. The senior year is totally composed of electives with the exception of a required clinical pharmacology course. The renewal effort was a multiphased initiative beginning with a complete curriculum review and pilot phase. The second phase focused on recommendations for curriculum changes and was followed by the final or implementation phase. This PBL pilot project's purposes were to demonstrate proof of the effectiveness of PBL as a teaching tool; to gain first-hand experience with PBL to allow us to make informed decisions about its eventual role in the curriculum; and to determine if a single instructor acting as facilitator by rotating among small groups would be a feasible alternative to the one-facilitator-to-one-group method that is commonly used.
MATERIALS AND METHODS

The demonstration project for PBL targeted the ophthalmology segment of the Introduction to Clinical Medicine (ICM) course for second-year medical students. The goals of the session were to teach the basic eye examination to students, introduce some basic (common) eye problems to second-year medical students; review history and examination skills taught in ICM; reinforce basic science in a clinical problem setting; introduce students to alternative learning experiences; and generate hands-on faculty experience with PBL.

In brief, PBL is a student-centered learning technique that presents students with realistic problems as they would occur in clinical practice; requires students to determine what they need to learn to take the next step in addressing the problem; and requires them to engage in self-determined learning and then return to their group session with a faculty facilitator to apply the new knowledge to the problem and reassess their learning. The problems should be appropriate for the students’ knowledge level and relevant to both common and serious problems encountered in clinical practice.

By way of overview, the procedure adopted would be most like the case-based method of PBL.7 The basic protocol consisted of small student groups that were given a clinical situation reflecting 1 of 4 different problems; eg, sudden visual loss. Each small group was instructed to develop a working hypothesis; to complete the patient problem work-up, examination, and tests; to use any available resources to assist in reappraisal of their original hypothesis; and then to present their final hypothesis to the whole group for discussion. Their experiences were evaluated with a pretest and posttests plus a postcourse assessment of student satisfaction.

For each 3-hour session, the students self-selected into 4 approximately equal-sized working groups (3-4 students per group). The problems were modeled after the standards recommended by Barrows.8 Each case simulated an actual patient encounter. All cases used a master guide of all the history questions and physical examinations, along with relevant diagnostic and laboratory tests. Every casebook incorporated (in separate sections) the presenting complaint, history data, physical (ocular) examination elements, diagnostic and laboratory test data, and appropriate special visual aids such as fundus photographs, ultrasonograms, magnetic resonance images, and so on.

Problems were developed in 4 categories (sudden visual loss, visual loss, trauma, and red eye) with 4 individual and related cases created in each category. These topics were selected because they represented common eye problems as well as potentially serious sight-threatening entities or disorders of significant social impact, such as blindness from diabetes. None of this material had been covered previously in the students’ ICM lectures.

The basics of a standard eye examination were taught by having the students follow the format of a complete ocular examination, starting with vision testing and concluding with a dilated fundus examination, as found in their casebooks. This way the students learned the proper order of the examination and they obtained all the physical examination information from using their casebooks, as all the elements (questions and answers) of the eye examination were included.

The students were given written instructions, objectives, question guides, and problem books at the beginning of the session. Each working group was asked to formulate a hypothesis based on the patient’s chief complaint, age, sex, and race. Each group developed and listed their ranked hypotheses on the board for the entire group. The group was then instructed to use their question guides to obtain a history, complete an appropriate eye examination in an organized sequence, to obtain specific ancillary ophthalmic examinations, and acquire other information from indicated laboratory and diagnostic studies. The students were encouraged to be selective in their use of the question guide to more realistically simulate an actual patient encounter. They were allotted 2 hours to analyze their data; to review, reassess, and synthesize their original hypothesis; and to present their final solution based on the acquired knowledge to the whole group. Each working group had access to 4 resource eye texts and was encouraged to use the adjacent ophthalmology library for any other inquiry. The faculty acted as a facilitator and not a resource. The entire group was engaged in the discussion on the decision-making processes that each group used. At the conclusion, the facilitator reviewed the key points from each case.

We departed from the usual PBL protocol in several respects. Some specific faculty-generated learning goals were provided as part of these small-group sessions and the entire experience was limited to a single 3-hour period. In addition, we used only a single facilitator (who was also a content expert) to circulate among the working groups. This is an important distinction because it has a direct bearing on the cost comparisons between PBL and traditional instruction. By having a single facilitator for 4 groups, the institutional costs are substantially reduced; however, it may be at the loss of quality of group interactions.

EVALUATION DESIGN

To determine if this approach to PBL yielded the benefits of student sat-

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of Students</th>
<th>Pretest Scores</th>
<th>Posttest Scores</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudden visual loss</td>
<td>31</td>
<td>2.45 (1.15)</td>
<td>4.65 (0.49)</td>
<td>10.55*</td>
</tr>
<tr>
<td>Visual loss</td>
<td>15</td>
<td>2.93 (0.70)</td>
<td>4.33 (0.62)</td>
<td>5.96*</td>
</tr>
<tr>
<td>Trauma</td>
<td>14</td>
<td>2.64 (1.08)</td>
<td>3.71 (0.61)</td>
<td>3.51†</td>
</tr>
<tr>
<td>Red eye</td>
<td>15</td>
<td>3.33 (1.11)</td>
<td>4.80 (0.41)</td>
<td>5.05*</td>
</tr>
</tbody>
</table>

*p<.01.
†p<.05.
satisfaction and gains in knowledge obtained in other studies,1,2 a pretest was administered in the first 5 minutes of the session. The same test was given again at the end of the session as a posttest. This test consisted of 5 items from that day’s problem category: 1 from each of the 4 individual cases and the fifth based on the eye examination. The 4 problem topics were cycled to reduce “contamination” by those students who had not yet had their small-group sessions. Because there were 5 sessions of students involved in the study, 2 received the sudden visual loss problem topic while 1 session each had the other 3 topics. The student satisfaction questionnaire was given at the end of the session and was composed of 7 Likert-type questions with 6 response options ranging from strongly agree to strongly disagree, plus 3 open-ended questions.

**SUBJECTS**

Second-year medical students enrolled in the first half of the ICM course, prior to receiving the ophthalmology lectures of this course. The students were without prior exposure to ophthalmology (they had not had their 10 hours of didactic second-year ophthalmology lectures in the ICM course yet) except for a 3-hour introductory ophthalmoscopy workshop in their first year.

**RESULTS**

Table 1 shows the pretest and posttest means and SDs and the t tests for related groups testing the statistical significance of the knowledge gains. Also shown are the results for each question on the participant satisfaction questionnaire.

Students showed statistically significant increases in knowledge from the experience for all 4 problem categories. Knowledge score gains ranged from 1.1 to 2.2 points and averaged 1.7 points. Expressed as percent correct, scores increased from a mean of 55% pretest to 89% posttest. In terms of statistical effect sizes, they ranged from 0.99 to 2.00 and averaged 1.56. Cohen9 defines effect sizes exceeding 0.80 as being large, so those found in this study could be considered extremely large.

Student satisfaction with the PBL experience was overwhelmingly positive, with 93% agreeing that they enjoyed the format. Further, 85% agreed with the statement that they learned more than they would have in the traditional format (Table 2).

**COMMENT**

This study examined the extent to which a pilot project, aimed at assessing the benefits of modified PBL, could produce the benefits shown with other forms of PBL. It would also enable a medical school in the process of curriculum renewal to gain insights into PBL. The results showed extremely large knowledge gains and high levels of student satisfaction. These findings are similar or superior to those found in other studies. They were also achieved with only 1 facilitator for 4 simultaneous small groups, with 3 to 4 students per group, opening the possibility for more cost-effective implementation of PBL than has been used previously.

The gains in knowledge, while encouraging, need to be interpreted with caution. Owing to fairly tight time constraints, the tests had to be short and we did not use a control group during this pilot study. It is possible that the pretest alerted the students to specific content that was important to learn and effectively became part of the treatment (pretesting effects). Future research will need to include a control group to obtain a clearer picture of the effectiveness of this form of PBL.

While a controlled comparison would have yielded a stronger study, our intent was more modest—to demonstrate proof of concept. We feel that our study successfully demonstrated this based on the data collected. We were able to implement PBL in a less faculty-intensive manner than is typically the case while enjoying some of the desirable student satisfaction outcomes obtained with the more faculty-intensive approaches. We hope this study will stimulate future research using methods that can determine the effectiveness of the treatment in a controlled manner.

Our success with using a single facilitator for the 4 groups may be due in part to our students having completed the basic science portion of their education. They may be better equipped to engage in the self-directed learning process than students who do not have such a thorough basic science background. Thus, this model may not be applicable to teaching the rudiments of basic science concept, as is PBL’s.

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**Table 2. Satisfaction**

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt comfortable with PBL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBL was too difficult</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I learned more from PBL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBL was too structured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I prefer the independence and initiative required for PBL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructor was helpful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall I enjoyed PBL</td>
<td></td>
<td></td>
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*Data are presented as number (percentage). PBL indicates problem-based learning.*
common role. Further research will be needed to determine if this more cost-effective PBL method can be successfully implemented with students at earlier stages in their medical education.

An additional point worth noting is that we gained time efficiency by using a relatively structured form of PBL. Students were given instructor-generated learning objectives to work from and the bulk of the resources necessary to carry out almost all investigations were readily available within the conference room and adjacent departmental library, a relatively small area. Thus, student investigations did not require them to visit remote resource areas to search a literature database, as can be the case.

While the instruction in ophthalmology was given in the PBL format only, and may introduce bias because the traditional didactic method of instruction was not experienced by this group, we believe that the students could reasonably generalize from their experience with other content to the PBL ophthalmology content. The validity of this cannot be answered with certainty, but we believe there is worth in their response to the question of whether they preferred the PBL format to their usual instructional format, enough so to proceed to the next level of assessment—introducing it into the curriculum.

Despite the potential for pre-testing effects to account for some portion of the learning gains and concern over the applicability of this model to more neophyte learners, these results are extremely beneficial because they provided our institution with first-hand PBL experience at a point when decisions were being made about changes in the curriculum. The decision to adopt PBL at our institution was based on a consideration of all the data, not just our study. The fact that we had a positive experience was one of those factors that led our institution to adopt case-based learning on a broad scale across the curriculum.

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REFERENCES


From the Archives of the ARCHIVES

A look at the past . . .

Knives with handles of different materials were exposed for varying periods to the action of a number of antiseptic agents. As a result of these experiments, alcohol was found to be harmless for short exposures (less than twenty-four hours). Prolonged exposure caused rusting. Formaldehyde gas given off by formol in a closed vessel was harmless within an hour or two. When the exposure was continued for twenty-four hours, small whitish spots appeared, which could be wiped off, but left a slightly roughened surface.