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Problem-based Learning versus Traditional Lecturing in Pharmacy Students' Short-term Examination Performance

JUDY W.M. CHENG[a,*], ANTONIA ALAFRIS[b], HAROLD L. KIRSCHENBAUM[c], MICHELLE M. KALIS[d] and MARTIN E. BROWN[e]

[a]*Arnold and Marie Schwartz College of Pharmacy and Health Sciences, Long Island University, Brooklyn, NY USA;* [b]*Kingsbrook Jewish Medical Center, Department of Pharmaceutical Services, Brooklyn, NY USA;* [c]*Arnold and Marie Schwartz College of Pharmacy and Health Sciences, Long Island University, Brooklyn, NY USA;* [d]*School of Pharmacy-Boston, Massachusetts College of Pharmacy and Health Sciences, Boston, MA USA;* [e]*Arnold and Marie Schwartz College of Pharmacy and Health Sciences, Long Island University, Brooklyn, NY USA*

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The purpose of this study was to compare problem-based learning (PBL) and traditional lecturing (TL) in Pharm.D. students' performance on pharmacotherapeutic examinations. Fourth-year Pharm.D. students were divided into two groups: Group A ($n = 186$), enrolled in Pharmacotherapeutics II (PH210), Fall 1999, were taught hyperlipidemia by PBL and thromboembolic diseases by TL; Group B ($n = 187$), enrolled in Fall 2000, were taught thromboembolic diseases by PBL and hyperlipidemia by TL. Student performance was assessed via multiple-choice examinations. For hyperlipidemia examination scores, Group B students performed statistically and academically significantly better (defined as >5% difference) on the total score (78.6 vs. 55.6%, $p < 0.001$), on analytical questions (81.5 vs. 51.1%, $p < 0.001$) but not on recall questions (74.3 vs. 83%, $p > 0.05$) than Group A. For thromboembolic diseases examination scores, Group A did as well as Group B in analytical questions (73.6 vs. 71.3%, $p > 0.05$), significantly better in total scores (72.2 vs. 69.2%, $p = 0.047$) and recall questions (73.8 vs. 63.0%, $p = 0.001$). Teaching hyperlipidemia by PBL resulted in statistically and academically significantly lower examination scores; this difference was not noted when thromboembolic diseases was the topic. Limitations include large class size, variations in examination questions and the possibility that certain topics may be more difficult for students to master using PBL. Continuation of long-term data collection will further determine if PBL helps students to develop critical thinking and problem solving skills.

Keywords: Problem-based learning; Examination performance; Pharm. D; Pharmacotherapeutics

INTRODUCTION

Problem-based learning (PBL) is a method of teaching that utilizes a problem—e.g. a patient case or practice-related scenario—to stimulate the acquisition of information and the application of it to solve problems (Barrows and Tamblyn, 1980). In PBL, a problem is the initial step that the student encounters in the learning process. The patient case or other problem serves as the primary method for acquiring and applying knowledge (Barrows and Tamblyn, 1980; Colvin and Wetzel, 1989; Kaufman *et al.*, 1989; Bickley *et al.*, 1990; Donner and Bickley, 1990; Patel *et al.*, 1991; Donner and Bickley, 1993). The case or problem serves as a focus for the application of reasoning skills and for the research that is needed to understand the steps required to solve the problem (Barrows and Tamblyn, 1980). When a patient case is used in PBL, it is not offered as an example of prior learning; rather, it is used to stimulate student reasoning and learning. Whether the problem is simple or complex, a systematic approach of identifying, solving and preventing future problems is used (Delafuente *et al.*, 1994; Fisher, 1994; Culbertson *et al.*, 1997; Brandt *et al.*, 1998; Sibbald, 1998; Catney and Currie, 1999; MacNair, 1999; Ross *et al.*, 1999).

PBL was first utilized in medical schools to accommodate the growing volume of knowledge

*Corresponding author. E-mail: jcheng@liu.edu

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required to practice medicine in an environment in which there are insufficient lecture hours to cover all of the required material. PBL has been successfully implemented and demonstrated to have favorable outcomes as modeled at McMaster University (Colvin and Wetzel, 1989; Kaufman *et al.*, 1989; Bickley *et al.*, 1990; Donner and Bickley, 1990; Donner and Bickley, 1993). Pharmacy education has begun to investigate the implementation of PBL in curricula due to the expanding volume of practice-related knowledge—similar to that faced by medicine—and to the growing responsibility of pharmacists to provide patient-oriented care (i.e. pharmaceutical care) (Shih *et al.*, 1999). Nevertheless, the impact of PBL in pharmacy education has not been adequately evaluated.

Arnold and Marie Schwartz College of Pharmacy and Health Sciences of Long Island University implemented an entry-level Doctor of Pharmacy (Pharm.D.) degree program in the Fall of 1998. One of the overall objectives of the program was to implement new teaching strategies in order to develop students' problem-solving skills and critical thinking ability. It was believed that if these abilities were enhanced, students would be better able to accumulate the rapidly growing volume of pharmaceutical knowledge and be better equipped to provide pharmaceutical care. To address this objective, PBL and small group recitation classes are now used throughout the curriculum. For example, in the new entry-level curriculum, the pharmacotherapeutics series of courses utilizes a combination of traditional lecturing (TL) and selected topics taught by PBL in a large class session. Small group recitations are used to re-enforce materials learned from TL and PBL.

Implementation of PBL requires effort and commitment from both faculty and students. As a result, initial resistance from faculty and students is to be expected. Additionally, since there are few long-term positive outcome data in pharmacy curriculum, widespread implementation of PBL may not be prudent. Assessment of students' long-term outcomes to demonstrate that the teaching method is achieving its goals is needed to reassure students and faculty that the effort devoted to PBL is worthwhile. Long-term outcomes, however, may not be apparent until after students graduate and have been engaged in practice. It is also important to assess short-term outcomes of PBL, such as examination scores and the ability to solve simulated patient cases. These data are needed to determine whether PBL jeopardizes short-term academic achievement.

The goal of the present study was to develop, implement and assess in the short-term PBL in a pharmacotherapeutics course. PBL was compared to TL in relation to the ability of entry-level Pharm.D. students to solve clinical patient problems in two therapeutic topics areas (hyperlipidemia and thromboembolic diseases) taught in a fourth year pharmacotherapeutics course. Specific objectives of the study were two-fold:

1. Implement PBL into a pharmacotherapeutics course (Pharmacotherapeutics II–PH 210) in the Fall 1999 and Fall 2000 semesters (PH 210 was offered each fall) and
2. Evaluate the effect of PBL vs. TL on students' examination scores for the two selected therapeutic topics (hyperlipidemia and thromboembolic diseases).

METHOD

Fourth year (second professional year) entry-level Pharm.D. students enrolled in PH 210 during Fall 1999 (Group A: $n = 186$) and Fall 2000 (Group B: $n = 187$) semesters participated in the study. Class rosters were compared. Those students who failed the course in 1999 and were repeating it in 2000 were included only for Group A. Two topics taught in the course (hyperlipidemia and thromboembolic diseases) were selected for the study. These two disease states were selected because there are official practice guidelines published for each (Dalen and Hirsh, 1998; National Cholesterol Education Program, 1999). These guidelines present approaches to treatment that are specific and systematic; thus it was believed that it might be easier for students who are beginning to master the concept of PBL to self-learn these two disease states. Group A students learned hyperlipidemia using the PBL approach and thromboembolic diseases using the TL approach; Group B students learned hyperlipidemia using the TL approach and thromboembolic diseases using the PBL approach. Demographic data were collected from the students to determine their previous experience with PBL. This project was approved by the Institutional Review Board of Long Island University.

Development of PBL Patient Cases and Examination Questions

Goals and objectives for the PBL sessions were developed (hyperlipidemia in Fall 1999 and thromboembolic diseases in Fall 2000) to provide a focus for the content of the patient cases and to develop examination questions for the instructors. These goals and objectives, however, were not provided to the students, in accordance with the theory of PBL. Specifically, a component of the PBL learning experience is for students to identify drug-related problems, define their own objectives and search for the answers without additional assistance (Donner and Bickley, 1993).

Based on the learning objectives, five patient cases were developed for each topic along with corresponding and detailed answer keys (the latter were developed for the purpose of grading the pharmaceutical care plans [PCPs]). These cases were reviewed by two pharmacy faculty members from two other institutions to ensure that they were suitable for students at this level of the program. Two weeks prior to the PBL sessions, students were provided a package that included the patient cases and suggested reading materials.

Every student was expected to develop optimal PCPs for each simulated patient case provided. It was expected that the PCPs include a list of patient problems, pharmacotherapeutic goals, recommendations for therapy, specific desired endpoints, monitoring parameters and monitoring frequency. The suggested reading list included materials that would be helpful to develop the PCPs. Students were encouraged to work individually, do their own literature search and consult other reference sources if needed. The faculty members assigned for the specific topic were available to meet with students, should they have any questions regarding the PBL package. On the day of the PBL sessions, the PCPs were collected for purposes of assessment. The instructor reviewed the cases with the students in a designated two-hour PBL session. PCPs were graded using the detailed answer keys.

Regardless of whether the topics were taught by PBL or TL that semester, the content was tested as part of a midterm examination using multiple-choice questions (some were case-based). The same instructor constructed multiple-choice examination questions for hyperlipidemia and thromboembolic diseases for both Fall 1999 and Fall 2000 semesters.

Data Analysis

Demographic data and the overall examination scores of the two specific topics chosen were compared between groups. Furthermore, examination questions pertaining to hyperlipidemia and thromboembolic diseases were categorized as testing either knowledge (recall) or analytical skills. Since some questions were identical between the two semesters, examinations were not returned to students (although they were encouraged to review them with the instructor). This was to ensure that, from Fall 2000, they would not have previewed some of the identical questions. Students' performance in these questions were compared between groups based on the following four categories (a question could belong to more than one group):

1. Total: all questions pertaining to the topic;
2. Similar: questions testing the same learning objective that are either exactly identical, written grammatically different from one year to the next (with the same distractors) and questions testing the same objectives but having different choices (distractors)—Fall 1999 compared with Fall 2000—for students to select;
3. Testing of knowledge (recall-only); and
4. Testing of analytical skills.

Student's *t*-test was used to compare the examination scores of the two groups and scores in each category of questions. A probability value of less then 0.05 was considered statistically significant. In addition to evaluating statistical significance, "academic significance" was defined as a difference of five percent or greater between Fall 1999 and Fall 2000 examination scores. Five percent was chosen based on the fact that it represented a one-half grade elevation in our curriculum (i.e. from B + to A, from B to B + , from C + to B, etc.), and therefore, would be viewed as important by both students and faculty.

RESULTS

A total of 186 students from Fall 1999 (Group A) and 192 from Fall 2000 (Group B) were enrolled in PH 210. Five students in the Fall 2000 group were excluded from data analysis for Group B because they were repeating the course; however, they were included as part of the Fall 1999 group for data analysis (therefore, Group B had 187 students). No student from Group A was repeating the course, as Fall 1999 was the first year, PH 210 was offered as part of the new entry-level Pharm.D. program.

Demographic Data

A total of 167 (90%) students in Group A and 109 (58%) in Group B completed and returned the demographic questionnaire. No statistically significant differences in demographic characteristics were observed between the two groups (Table I). In both groups, more than 50% of the students (those who returned the demographic questionnaire) were female. Sixty-eight percent of students in Group A and 70% of students in Group B were 20–25 years of age. The overall grade-point average (GPA) of the students was similar between the two groups, with the highest percentage of students (32.9% in Group A and 35.5% in Group B) having a GPA between 3.1 and 3.4 (using a scale of 0–4.0). As noted in Table I, 23 and 30% of the students in Groups A and B, respectively, had a previous college degree, with the greatest percentage having a Bachelor of Science degree in chemistry (Group A: 2.4% and Group B: 13.9%) prior to pursuing a pharmacy degree. There were no statistically significant differences between the types of college degrees received between

TABLE I Demographic characteristics of fall 1999 and fall 2000 students

Characteristic*	Fall 1999 ($N = 167$)	Fall 2000 ($N = 109$)
Sex-no. (%)†		
Female	115 (68.8)	67 (61.5)
Male	47 (28.1)	42 (38.5)
Age-yr		
< 20	3 (1.8)	1 (0.9)
20–25	113 (67.7)	76 (69.7)
26–30	26 (15.6)	14 (12.8)
31–35	9 (5.4)	8 (4.8)
> 35	12 (7.2)	19 (17.4)
Self-reported grade point average		
< 2	9 (5.4)	0 (0)
2.0–2.4	23 (13.8)	16 (14.7)
2.5–3.0	36 (21.6)	23 (21.1)
3.1–3.4	55 (32.9)	38 (35.5)
3.5–4.0	33 (19.8)	27 (24.8)
PHP 414‡ (taken previously)	18 (10.8)	8 (7.3)
Previous degree	39 (23.4)	33 (30.3)
Health related courses	6 (3.6)	7 (6.4)
PBL courses	2 (1.2)	0 (0)
Past work		
Community pharmacy	73 (43.7)	60 (55)
Hospital	11 (6.6)	7 (6.4)
Community and hospital	12 (7.2)	9 (8.3)
Long-term care	4 (2.4)	0 (0)
Others	5 (3)	3 (2.8)
Current work		
Community pharmacy	72 (43.1)	57 (52.3)
Hospital	19 (11.4)	9 (8.3)
Industry	1 (0.6)	0 (0)
Others	3 (1.8)	6 (5.5)
Future work		
Community pharmacy	34 (20.4)	14 (12.8)
Hospital	36 (21.6)	22 (20.2)
Community or hospital	10 (6)	11 (10.1)
Long-term care	4 (2.4)	2 (1.8)
Industry	19 (11.4)	12 (11)
Community or industry	4 (2.4)	1 (0.9)
Hospital or industry	5 (3)	6 (5.5)
Others	24 (14.4)	16 (14.7)
Not known	22 (13.2)	22 (20.2)

*$p > 0.05$ (comparing Fall 1999 with Fall 2000). †Percentages may not sum to 100 because not all questions were answered. ‡PH414: A similar Pharmacotherapeutics course offered in the previous Bachelor of Science in Pharmacy Program.

the two groups. Six students in Group A and seven in Group B had completed one or more health science course(s). Two out of those six students in Group A had exposure to PBL as compared to none of the seven students in Group B. More than half of the students had previous pharmacy work experience (62.9% in Group A and 72.5% in Group B). Approximately, half of the students in each group were working at the time of the study. A smaller percentage of students in Group B (12.8%) wanted to eventually practice pharmacy in a community setting compared with those in Group A (20.4%), but a similar percentage (21.6% in Group A and 20.2% in Group B) wanted to have a career as a hospital pharmacist.

Examination Scores

The overall course averages (including all examinations and recitations) were 72.7% (±8.3) and 75.9% (± 8.5) for Groups A and B, respectively. The difference between the averages (3.2%) was neither statistically nor academically significant.

Hyperlipidemia Examination Scores

Hyperlipidemia was taught using PBL in Group A and TL in Group B. There were seven multiple-choice questions on hyperlipidemia on Group A's examination and eight questions on Group B's examination. The discrepancy in the number of questions was due to the difference in scheduled examination dates; different amounts of material on each examination could be covered. Categorization of the hyperlipidemia questions between the two years resulted in five questions being similar (none exactly identical, two phrased grammatically differently and three having different distractors). For these seven questions, one was judged to be recall-only and six were analytical. Out of the eight hyperlipidemia questions in Group B, three were recall-only and five were analytical. The mean

TABLE II Examination scores of fall 1999 and fall 2000 students

Exam	PBL-Fall 1999 ($n = 186$)	TL-Fall 2000 ($n = 187$)	Difference*
Hyperlipidemia -% (no.)†			
Total	55.6 (7)	78.9 (8)	−23.3‡
Analytical	51.1 (6)	81.6 (5)	−30.5‡
Recall	83 (1)	74.3 (3)	8.7
Similar	58.1 (5)	84.3 (5)	−26.2‡
Analytical	52.2 (4)	86.7 (4)	−34.5‡
Recall	81.6 (1)	83.9 (1)	−2.3‡
	PBL-Fall 2000 ($n = 187$)	TL-Fall 1999 ($n = 186$)	
Thromboembolic diseases			
Total	69.2 (17)	72.2 (17)	−3.0‡
Analytical	73.6 (10)	71.3 (11)	2.3
Recall	63 (7)	73.8 (6)	−10.8‡
Similar	74.9 (10)	76.6 (10)	−1.7
Analytical	75.0 (4)	74.1 (4)	0.9
Recall	74.3 (8)	84.2 (8)	−9.9‡

*Difference between Fall 1999 and Fall 2000 examination scores; academic significance was achieved if the difference was >5. †Number of questions belonging to each category. ‡$p < 0.05$.

percentage score for the seven hyperlipidemia questions in Group A was 55.6% and the mean percent score on the eight questions in Group B was 78.9% (Table II). This was statistically and academically significant ($p < 0.05$ and >5% different). For the analytical questions, the students in Group A had a mean score of 51.1% while the students in Group B had 81.6%, which again was both statistically ($p < 0.001$) and academically different. For the recall-only questions, Group A had a mean score of 83%, while Group B had 74.3%, which was not statistically significant but academically significantly different. For the five similar questions, Groups A and B scored 58.1 and 84.3%, respectively; scores were statistically and academically significantly different ($p < 0.001$).

Thromboembolic Diseases Examination Scores

Thromboembolic diseases were taught as TL in Group A and PBL in Group B. There were 17 multiple-choice questions on thromboembolic diseases on each examination. Out of the 17 questions for Group A, 11 were analytical and 6 were recall-only. For Group B, 10 were analytical and 7 were recall-only. Categorization of the thromboembolic diseases questions between the two groups resulted in ten being similar (four identical, four written grammatically differently and two having different distractors). The overall average mean score for Group A on the thromboembolic diseases questions was 72.2%, with a mean of 71.3% on the analytical questions, and 73.8% on the recall-only questions (Table II). The students in Group B scored an overall average of 69.2% on the thromboembolic diseases questions with a mean of 73.6% on the analytical questions and a mean of 63% on the recall-only questions. Different from the hyperlipidemia questions, the overall score for thromboembolic diseases was statistically different ($p = 0.047$) but not academically different between groups. When broken down into analytical and recall questions, Group A scored statistically and academically significantly higher in recall questions then Group B (73.8 vs. 63%, $p < 0.001$) but not in analytical questions. Out of the 10 similar questions, there were no differences between the total scores (Group A vs. Group B, 76.6 vs. 74.9%, $p = 0.422$) and scores of analytical questions (Group A vs. Group B, 74.1 vs. 75.0%, $p = 0.557$). However, there is a statistically and academically significant difference in scores of similar recall questions (Group A vs. Group B, 84.2 vs. 74.3%, $p = 0.004$).

Hyperlipidemia PCPs

Group A students learned hyperlipidemia by developing PCPs for five patients with the disease. These PCPs were assessed using standard answer keys. Students scored 77.2% [±15.9] on these PCPs.

Thromboembolism PCPs

Group B students learned thromboembolic disease by developing PCPs for five patients with the disease. These PCPs were graded using standard answer keys. Students scored 77.1% [±29] on these PCPs.

DISCUSSION

The benefits of PBL have been demonstrated in medical curricula (Barrows and Tamblyn, 1980; Colvin and Wetzel, 1989; Kaufman *et al.*, 1989; Bickley *et al.*, 1990; Patel *et al.*, 1991; Donner and Bickley, 1990; 1993) but have only begun to be tested and investigated in pharmacy education (Love and Shumway, 1983; Strand and Cipolle, 1987; Busto *et al.*, 1994; Delafuente *et al.*, 1994; Fisher, 1994;

Sims, 1994; Winslade, 1994; Raisch *et al.*, 1995; Nii and Chin, 1996; Hrubet *et al.*, 1996; Culbertson *et al.*, 1997; Herrier *et al.*, 1997; Brandt *et al.*, 1998; Catney and Currie, 1999; Cheng *et al.*, 2002; Ives *et al.*, 1998; Lubawy and Brandt, 1998; Sibbald, 1998; MacNair, 1999; Rhodes, 1999; Ross *et al.*, 1999; Shih *et al.*, 1999). Developing innovative teaching strategies is necessary due to the expansion of practice-related knowledge, as well as to ensure that pharmacists have the skills needed to provide pharmaceutical care. In addition, the use of PBL and other innovative modalities is encouraged by the American Council on Pharmaceutical Education (ACPE). The ACPE Accreditation Standards recommended that pharmacy education provide for basic outcomes and competencies including critical thinking, scientific comprehension, communication and problem solving skills (American Council on Pharmaceutical Education, 1997; American Council on Pharmaceutical Education, 2000).

Ives and colleagues at the University of North Carolina School of Pharmacy developed, implemented and evaluated a three semester, case-based, student-centered, integrated sequence of pharmacotherapy and medicinal chemistry course during the second and third years of the professional curriculum (Ives *et al.*, 1998). Throughout the sequence, students needed to complete a number of modules each concentrating on a specific disease state. During each module, students discussed patient cases in both small group sessions (1–2 h weekly or biweekly) and in a large classroom (6–10 h per-week), which combined TL and case-based instruction. Students were required to develop PCPs for the simulated patients prior to coming to class and to be prepared to participate in discussion. Students' grades for the course were based solely on short-essay and multiple choice examination questions. Following the implementation of the integrated courses, students completed exit surveys in order to assess their attitude towards the new curriculum. Students reported a generally positive attitude towards the new curriculum, with the majority of positive statements reaching an average of between 5.0 and 5.9 (based on a Likert-type scale of 1–6, in which 6 indicated strongly agree, 1 indicated strongly disagree). Specifically, the students reported that integration made the material more understandable than before. They also maintained that it was easier to apply new knowledge to solve a patient problem than prior to the curricular change. A less positive evaluation was given to the patient discussions held during the large classroom (about 100 students) sessions in which a number of students did not participate and were able to come to class unprepared. Interestingly, since the implementation of the integrated courses, clerkship preceptors subjectively reported overall improvement in the students' ability to identify and solve patient problems and to interact with other health care professionals.

Lubawy and Brandt at the University of Kentucky developed an instructional method called "micro-situation teaching" and employed it in 1997 to redesign an endocrine pharmacology course for students in the second professional year (Lubawy and Brandt, 1998). The instructor lectured for 20% of the time and the remaining 80% was devoted to using mini-patient cases as the primary teaching tool. The main reason for reconstructing the course was to apply some of the principles of PBL without requiring intensive resources from other faculty. Eighty students were enrolled in the course. In order to initiate critical thinking and problem-solving skills and to reinforce patient-specific decision making, the faculty approached the mini-cases from different perspectives by posing a series of "what-ifs." At the beginning of the semester, students were divided into groups of five and provided with the micro-situations for the semester. Every student was responsible for solving each mini-case prior to class and then discussing it with his or her group during class. Each member of the group was responsible for presenting part of the pharmaceutical care plan for the patient. To ensure that all students did their work, the faculty would give unannounced quizzes during selected sessions. Student performance on examinations (case-based and open-book) improved between 1996 and 1997. The 1996 students scored an average of 67.5% while the 1997 students achieved a mean of 84.6% (on the similar final examinations). Student evaluation forms were used to assess students' attitude towards the new learning process. Results appeared to be favorable towards using microsituations in learning endocrine pharmacology, but statistical analyses were not performed.

Winslade at the College of Pharmacy at the University of Toronto examined the effects of PBL in a large pharmacotherapeutics course ($n = 190$) (Winslade, 1994). At the beginning of each session, students were given a package of PBL material that consisted of patient cases, suggested readings on disease states and drug therapy and a therapeutics integration flowsheet that guided the students through a technique to identify, solve and prevent drug-related problems. During the semester, students were given three written examinations that required them to identify and manage a patient's drug-related problems using knowledge that they had acquired from assigned readings and class discussions. In addition to the patient cases, examinations included a case scenario in which the simulated patient suffered from a medication-related problem that was unknown to the students. In order for the students to solve the case, they needed to

read additional material that was attached to the examination paper. The point of the case scenario was to determine whether students were able to select relevant information and apply it to the patient case. At the end of the semester, 97% of the students rated the course as being valuable and 76% did not prefer a different teaching method.

The effect of PBL in the development of students' critical thinking and problem-solving skills has also been assessed in clerkship experiences. Raisch and colleagues developed and evaluated the effects of a PBL program in pharmacy externship rotations (Raisch *et al.*, 1995). Forty-five students at the University of New Mexico were randomized into the experimental ($n = 26$) and control ($n = 19$) groups. The former had eight two-hour PBL sessions (with preceptors who were trained to facilitate such sessions) in which students studied and discussed patient cases. During the PBL learning sessions, if a question arose that no student could explain, the facilitator asked whether it was a learning issue. If it was, students were asked to write the learning issue on the board (in their own words) and then research each issue and present the findings at the beginning of the next session. The primary endpoint of the study was the performance of students on the final examination, which consisted of multiple choice questions and simulated community and hospital patient cases (involving problems with patient compliance, drug interactions and contact with the prescriber). The students in the PBL group scored an average of 81% while students in the control group scored an average of 66.5% in the final examination; the difference was statistically significant ($p < 0.001$). Also, preceptors and students rated PBL as a valuable part of the externship program.

Nii at the University of Southern California compared clerkship performance (as measured by GPA) of pharmacy students who were taught using PBL to those who received TL prior to clerkship (Nii and Chin, 1996). During the third (first professional) year, students were randomly assigned to learn different topics through PBL ($n = 58$) or TL ($n = 60$) in one class for two semesters. In the final year of the program, students were assigned to clerkships. GPAs between the two groups were significantly different (3.34 ± 0.4 vs. 3.1 ± 0.43, $p < 0.05$), with the PBL students scoring a higher average on the rotations than the TL students. Nevertheless, although statistical significance was achieved, the means were only 0.24 points apart.

We conducted another study comparing TL and patient-based approach in pharmacy students' ability to evaluate hypertensive patients (Cheng *et al.*, 2002). The study was also aimed to determine whether students perceived greater value in learning using a patient-based approach vs. TL. Senior students in community pharmacy clerkships for four consecutive semesters evaluated hypertensive patients based on national treatment guidelines. Only students in community pharmacy clerkship during the last two semesters received a lecture on the latest treatment guidelines (TL). Students ($n = 284$) evaluated 821 patients. Correct evaluations in the patient-based approach group and TL groups were 68 and 66%, respectively. Differences existed in perceptions of the project as a valuable experience (patient-based approach vs. TL 89 vs. 75%, $p = 0.007$) and its usefulness as a teaching method (patient-based approach vs. TL 82 vs. 69%, $p = 0.021$). Students demonstrated similar critical thinking abilities but perceived greater value in learning by the patient-based approach than by TL.

With preliminary data in pharmacy education demonstrating the potential positive effect of PBL, the current project was designed to compare the short-term effects of PBL with TL in entry-level Pharm.D. students' performance on examinations. The major purpose was to reassure faculty and students that, with the tremendous amount of effort invested in innovative teaching methods such as PBL, these methods will not jeopardize students' short-term academic performance and may possibly (still to be proven) enhance students' long-term critical thinking or problem solving ability. The present study demonstrated no significant difference in overall course average. In questions pertaining to thromboembolic disease, TL students did statistically better but not academically better. When broken down into analytical and recall questions, PBL and TL students did the same on analytical questions while TL students did better on recall questions. For hyperlipidemia, the overall examination scores were statistically and academically better for TL students than for PBL students. TL students also did better in all categories of questions with the exception of recall questions, where there was no difference between the two groups. These results are in contrast to previous studies that showed PBL having a positive impact (Colvin and Wetzel, 1989; Kaufman *et al.*, 1989; Bickley *et al.*, 1990; Donner and Bickley, 1990; Donner and Bickley, 1993). Before one can discuss whether PBL has any impact on students' short-term examination performance, several limitations need to be addressed.

First, it is important to realize that not all examination questions between the semesters were identical. Specifically, many questions were similar but had different distractors. Some of these distractors may have altered the level of difficulty of these questions. Also, since only a few examination questions tested these two topics, any change in the difficulty index of the questions could greatly affect the overall average.

It is also important to note that Fall 1999 (Group A) was the first time PBL was implemented.

Both the faculty and students were learning how to coordinate and master the sessions in an optimal manner. In the following year, as the faculty gained more experience, one might expect to see a general improvement in student performance. In addition, students from Group B might have learned from Group A students what to expect in these PBL sessions. To avoid this "learning curve phenomenon," data probably should be repeatedly collected for several more years so that both faculty and students get accustomed to PBL.

Multiple-choice examination scores, also may not be the best measure of critical thinking and problem-solving skills that students acquire from PBL sessions; students may randomly guess on multiple choice questions and such questions might not be optimal to assess higher-level skills on Bloom's taxonomy (Bloom, 1956). Comparison of PCP scores may provide a better measure of students' critical thinking and problem-solving ability than scores on a multiple choice examination.

It is also interesting that PBL seemed to have more of a positive effect when used in teaching thromboembolic diseases than hyperlipidemia. This also may indicate that certain topics are more difficult for students to master via PBL, especially earlier in their career when they do not have a lot of practical experience. Therefore, faculty may want to select topics carefully for PBL.

Finally, PBL sessions in our college were conducted with a large class, which may have reduced the effectiveness of PBL in developing students' critical thinking and problem solving skills.

CONCLUSION

This study looked at examination performance in selected pharmacotherapeutics topics taught by PBL vs. TL. Hyperlipidemia in Group A and thromboembolic diseases in Group B were learned through PBL. Group A students scored statistically and academically significantly lower on the total and analytical hyperlipidemia examination questions than Group B but did similar on the recall questions. *Vice versa*, thromboembolic diseases was taught by TL in Group A and hyperlipidemia was taught by TL in Group B. Group A students scored statistically and academically significantly higher on the recall-thromboembolic diseases questions but the scores for the analytical-thromboembolic diseases questions were not significantly different between the two groups. This may be a reflection of the faculty gaining more experience in conducting PBL sessions and guiding students through them or that certain topics are more suitable to be taught by PBL than others. To demonstrate if that is the case, one should continue data collection for several more years so that both faculty and students get accustomed to PBL.

Although our study did not provide overwhelmingly positive results in support of PBL improving short-term examination performance, it is nevertheless important to note that measuring examination performance only provides a cross-sectional view of the efficacy of PBL. Following students longitudinally over the course of clerkships and post-graduation should be more reflective on whether PBL had an impact on students' critical thinking and problem-solving skills and whether it taught them how to obtain new knowledge and skills on their own. Faculty may wish to select topics carefully in applying PBL, as certain topics may be more difficult to master through it than others. This is especially the case early on in students' professional career when they lack real life practical experience.

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