

Student Perceptions About and Performance in Problem-Based Learning

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Abstract. Many graduate and professional programs include Problem Based Learning (PBL) as a mainstay in their curricula. For many undergraduate students, this is a change from a teacher-centered to a student-centered learning method. This study was undertaken to learn about perceptions and test performances of college students (N=116) enrolled in liberal education classes when PBL is used vs. traditional teaching methods. Results indicated students perceived traditional teacher-centered learning more favorably than student-centered PBL. Nevertheless, test scores were similar. Negative student perceptions about learning in PBL classes did not support either teacher observations of learning activity in the classroom or compromised test performances.

Keywords: Problem Based Learning, Teacher Centered Learning, Student Centered Learning

I. Introduction.

Problem Based Learning (PBL) was initially implemented as an alternative higher education teaching method in the 1970's at McMaster University's Medical School (Boud & Feletti, 1997). The primary reason for implementing PBL into the curriculum was to better prepare students for real-world problem solving. Medical professionals, when presented with a patient, do not always have all the information necessary to provide appropriate diagnosis and treatment. In particular, in emergency medicine, patients may not be able to communicate all pertinent information. The ability of professionals to distinguish what is known about a patient's condition from what needs to be known, and how to go about gathering information that will lead to addressing the patient's condition and solving a health-related problem, will determine the potential for a successful outcome. This type of learning process is not unique to medical school courses and scenarios. Similar real-world problems are often presented in the field of accounting, where, for example, an accountant is presented with a stack of paperwork and is asked to prepare a balance sheet or journalize a transaction. In addition to what is evident before her or him, the accountant will have to sort out what is known, what needs to be known, and how to go about gathering necessary information to solve the problem.

PBL has been successfully implemented in medical and professional education schools around the world (Alleyne et al, 2002; Sundglad et al., 2002; Quinlan, 2000; Albanese & Mitchell, 1993; Vernon & Blake, 1993). PBL is also emerging in undergraduate curricula as many universities and colleges undergo curriculum reform and are exploring new ways to effectively engage and teach students (Seaberry, 2002; Barr & Tagg, 1995). There is growing evidence that real-world type of questions and learning activities that are student-centered may be more valuable than traditional teacher-centered lectures in which most of the pertinent

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information is presented by the teacher, followed by a case study or assignment (Martin et al., 1998; Norman & Smidt, 1992). A goal of PBL is to prepare students for life-long learning by engaging them in active learning in which the students are responsible for discovering facts and uncovering key concepts. This approach contrasts with a traditional teacher-centered approach where key facts and concepts are presented to the students.

Three key features of PBL include:

- 1) Learning in context, where real life problems are presented;
- 2) Elaboration of knowledge through social interaction, where students work together in small groups; and
- 3) Meta-cognitive reasoning and self-directed learning, where independent thinking and life long learning is encouraged (Dahlgren & Dahlgren, 2002). In PBL, students are presented with a realistic problem without prior traditional lectures or presentations (Duch, Groh, & Allen, 2001). In the process of solving the problem, students develop knowledge of theory, practice, facts, concepts, and appropriate inquiry strategies related to the initial problem.

Success or failure of PBL depends upon students' taking responsibility for their own learning (Quinlan, 2000). Solomon (2001) reported that her masters level Physiotherapy students valued group process and work, as indicated by the following comment: "I learned that each member of the team has a role to play, not simply individuals working independently in a team setting, but that trust, patience, and respect for each member only makes the group stronger. That is what I learned—that I have a role to play to set up this environment." Nevertheless, PBL has been known to create tension in undergraduate students in studies where they reported dissatisfaction and fear. In particular, the transition from a traditional student to being a PBL student was described by Biley (1999) as being associated with feelings of frustration and uncertainty. It is speculated that once students undertake the transition, then negative perceptions about PBL will be reduced and benefits of PBL will be realized. Outcomes in the form of grades are important to the student in their perception of PBL. Undergraduate nursing students acknowledged benefits of PBL such as the ability to "find things out that we had no previous knowledge of, to go back at the end of the program and work at it, or change direction and follow our own interests and educational needs." (Biley, 1999).

Although PBL has been implemented and assessed in many graduate and professional school programs, few studies have focused on the impact of PBL in liberal education graduate and undergraduate programs. Many liberal education courses consist of primarily traditional teaching methods. Traditional teaching methods have been described as pedagogues where the teacher transmits knowledge in a securely anchored way to students. Primarily didactic teaching methods contribute to the student's "comfort zone" (Margetson, 1996). When roles are changed, for example, when the student is required to develop one's own plan of direction, the comfort zone changes, and tension develops. A key intention of PBL is that such tension may lead to learning material in a different way, creating opportunities for self-directed, deep learning (Dunkbase & Penick, 1990). The initial response to PBL seems to relate to the lack of a "comfort zone" where traditional roles are supposed to be played out with the instructor responsible for the teaching and the student processing the information for learning. Nardi & Kremer (2003) reported a common occurrence found in PBL classes- most students reported discomfort when attempting to solve ambiguous problems in health care. A "comfort zone" is not limited to students as teachers tackle issues such as the extent to which a teacher can "let go" as a facilitator, deal with tensions that arise in student groups, manage time effectively, and balance the need to deliver problem solutions in real time while still meeting the learning needs of students (Conway & Little, 2000).

Several studies have reported student and faculty concerns about PBL implemented in specific coursework and curricula in both pre-professional and professional schools (Alleyne et al., 2002; Sunblad et al., 2002). Nardi and Kremer (2003) used a naturalistic inquiry method (a combination of observation and questions) to learn about the degree of mindfulness undergraduate nursing students displayed about their own academic growth and the ability to link their learning activities to the degree of personal learning in the classroom. They were interested in determining how well students perceived they learned using PBL as well as how well test scores reflected learning.

One factor leading up to this study is the expectations by many professional schools, including medicine, nursing, physical and occupational therapy, that students have experience in PBL. In my role as an academic advisor, I have seen an increasing number of inquiries on graduate and professional school applications about students' experience with PBL. In my role as a teacher in higher education, I feel obliged to prepare students not only with content but also with appropriate tools needed to succeed in the process of learning. Due in large part to the inquiries by graduate and professional schools on PBL experiences of undergraduates, I introduced PBL into my undergraduate and graduate courses several years ago and noted whether the academic performance differed from traditional teaching methods. I also noted perceptions of the students, in part because of a strong impression of frustration that pervaded the classroom. I felt a strange sense of incongruity between what students wanted and what students needed.

The purpose of this study was to learn about the perceptions and test performances of college students enrolled in liberal education classes in which both PBL and traditional teaching methods are used. It was hypothesized that undergraduate and graduate students enrolled in a liberal education college would experience similar tensions as pre-professional students related to PBL teaching methods. It was further hypothesized that test performance would be inferior in students enrolled in courses which included PBL compared with students enrolled in classes that utilized mainly traditional teaching methods. The hypothesis that students in PBL would do worse on tests than students in traditional lecture was partly formed due to the high level of frustration among students that I perceived and the novelty of the PBL, student-centered approach to virtually all students. In this study, both quantitative and qualitative data are presented, as well as a naturalistic inquiry method by the instructor, that provide insight into undergraduate and graduate student learning, perceptions, and test performance associated with PBL in a liberal arts college setting.

II. Method.

This study was conducted at a midsized college, with a 15,000 student enrollment, located in a small town in a Midwestern state in the USA. It is considered to be a liberal arts college and its mission has an undergraduate focus with a few graduate programs having national recognition. It has a selective admission policy. The community served by the school is mainly Euro-Caucasian with approximately 10% minorities enrolled. Most of the undergraduate students reside on campus and range in age 18-24 years old. A majority of graduate students enroll as full time students and are supported by assistantships on campus. Participants in these studies had similar characteristics as the typical undergraduate and graduate student enrolled in the college, with an average GPA range of 2.8-3.6 for undergraduates and 3.0-3.7 for graduates. All students were volunteers who agreed to allow their test scores to be used in calculations and comparisons. They also agreed to allow their anonymous feedback to be qualitatively analyzed. All students completed informed consent forms and complied with the rules and regulations of Miami University's Human Subjects Internal Research Board.

Two separate studies, one involving undergraduate and the other, graduate students, were conducted during the academic year. The same instructor taught all class sections, both graduate and undergraduate. A total of 93 undergraduate students, 64% female and 36% male, enrolled in three sections of Exercise Physiology, a senior level class taken by students as either a required or elective course. The age range was 21-28 years. Not one student had experience with PBL methods in previous coursework. Thirty-one students were enrolled in a course that included PBL. Two other sections of the same course included mainly lecture presentations and enrolled 37 and 25 students. Learning objectives included understanding and describing basic anatomy and physiology of muscle, muscle development, muscle atrophy, and theories related to muscle movement and muscle growth.

Traditional lectures included slide presentations and case studies. PBL activities included problems given to students prior to the presentation of information required to address the problems. The instructor consulted a PBL text book (Duch et al, 2001) and web sites for examples of questions and brought to the classroom resources in the form of extra texts, journals, and video clips. PBL activities and questions were undertaken in small groups. Small group formation followed a modification of models presented by Biley (1999), Millis and Cottell (1998), and Van der Vleuten and Weigne (1990), with four students, each having a specific role: leader, devil's advocate, recorder, and reporter. Roles were changed throughout the course so that every student was responsible for each role at some point during the course. Organization of PBL was loosely structured around Biley's (1999) eight stages as shown in Table 1. And finally, and importantly, motivational aspects of the problem, as described by Chapman (2000) were taken into account: familiarity, relevance, dramatic appeal, significance, authenticity, and potential for group collaboration.

Table 1. Biley's (1999) PBL process.

Step 1.	Interpretation of the scenario, concept, and term clarification
Step 2.	Brainstorming
Step 3.	Organize the outcome of the brainstorm
Step 4.	Define problems and issues
Step 5.	Establish learning needs
Step 6.	Collect knowledge
Step 7.	Explore newly acquired knowledge in relation to established problems and I issues
Step 8.	Apply to scenario

These stages were described to students and then reduced to three major questions that challenged students as they attempted, with their fellow group members, to solve the problem: 1. What do we know? 2. What do we need to know? 3. How do we proceed in finding out what we need to know?

Twenty-three graduate students, 83% female and 17% male, enrolled in two classes, and participated in a separate study. The age range was 22-42 years. One class of 15 participated in PBL and a second class of 8 students participated in a traditional lecture format. The same material on cardiovascular health and age-related disease was presented using either PBL or traditional lecture presentations. The class was a graduate level course titled: Exercise, Age, and Health. This interdisciplinary class addresses physiological, social, and psychological forces that impact health and aging. Learning objectives included understanding and describing a healthy and diseased cardiovascular system, studying causes for disease, and distinguishing between aging and disease processes that affect cardiovascular structure and function.

The same examinations were given to graduate students both in the PBL class and in the traditional lecture format class. Similarly, undergraduates took the same examination. A one-way analysis of variance (ANOVA) was used to compare undergraduate mean grades between the two teaching methods: PBL and traditional, followed by Bonferroni post-hoc analyses tests, if significant differences were detected. A separate one-way ANOVA was also used to compare graduate mean grades between PBL and traditional teaching methods. The chi square test for independence was used to compare grade distribution among the different classes. In both types of analyses, ANOVA and Chi Square, the level of significance was set at 0.05. In addition to these two quantitative comparisons, qualitative information was recorded and categorized. The following open-ended question was posed to all students in the PBL class: "Please comment about the teaching method-PBL-used in this class." A similar question was posed to all students in the traditional lecture/presentation class: "Please comment about the teaching methods used in this class". Subjective feedback was provided by students in all courses and analyzed by determining core categories, which captured major themes of student comments. The instructor also recorded perceptions of students as they worked together in both the traditional and PBL classes in a journal following each class. These perceptions included notes on student engagement and assessment of focus and efficacy of small group discussions in the different classes.

III. Results.

A. Undergraduate Course Comparisons.

The mean grade for undergraduate students in the PBL class was $82.3 \pm 1.3\%$. Mean grades for the two traditional classes were 82.6 ± 1.3 and $80.7 \pm 1.7\%$. Grade distribution in the exams was similar and is shown in Figure 1.

ANOVA indicated that there were no differences among the mean test scores for students in PBL versus traditional lecture classes ($F_{2,89}=0.53$, $p=0.59$). Chi square test for independence indicated a critical chi-square value=9.48, but the calculated chi-square value=2.90, therefore, we could not reject the null hypothesis-that grade distribution was similar among the three classes. A cursory view of the data indicates a difference in grade distribution between the two traditional lecture classes when comparing the percentage of students scoring in the 60's, 70's, and 80's on the exam. Upon further analysis of the C grade, when combining cells into the grade of C and non-C scores, once again, the calculated chi-square value of 2.59 did not reach the critical chi-square value of 5.99. Therefore, at the 0.05 level of significance, we could not reject the null hypothesis and thus had to accept that the C grade distribution was similar among the three undergraduate classes. Furthermore, in both traditional lecture formats, 80% vs. 76% of

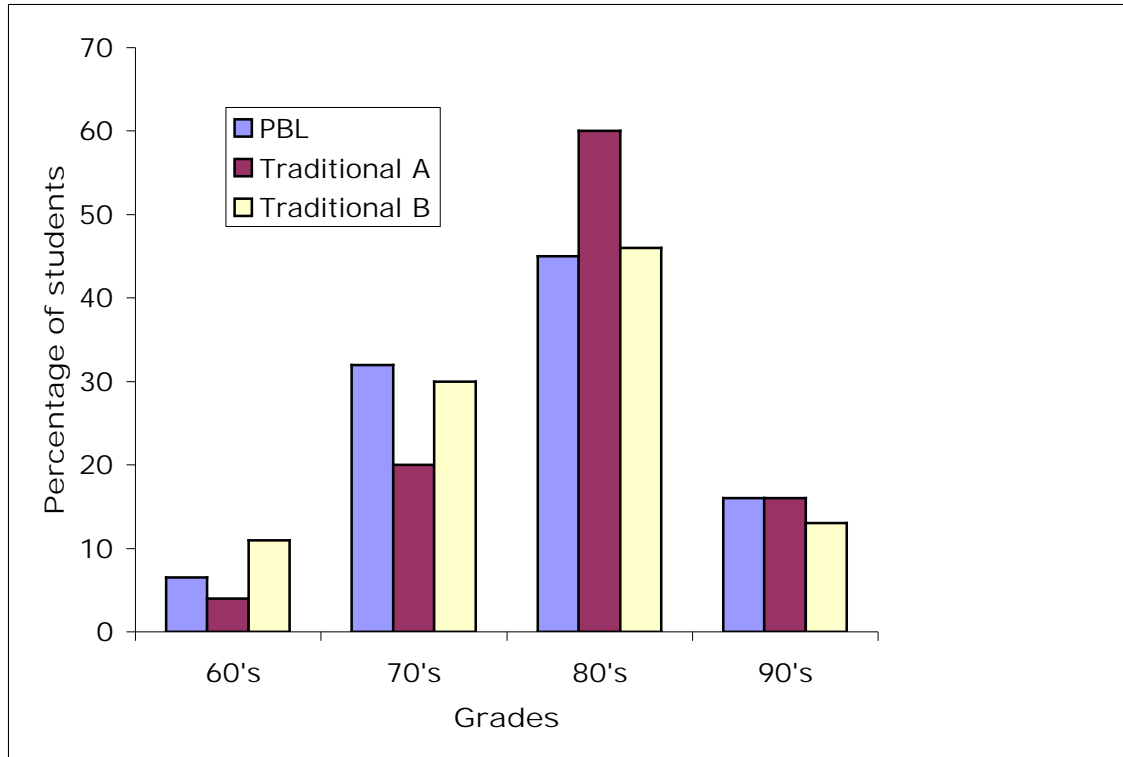


Figure 1. Grade Distributions in the Undergraduate Classes.

students scored in the 70's and 80's grade range. That average compared closely to 77% of students in PBL who scored in the 70's and 80's grade range.

Subjective feedback from undergraduate students in the class in which PBL was used, included the following categorized by whether the feedback supported PBL or not. Only two students provided positive feedback about PBL. Most feedback on PBL was categorized as negative. The following include samples of undergraduate student feedback.

Undergraduate student feedback that was supportive of PBL:

“I like interacting with other students in small groups.”

“Reading journal articles helped me learn more about the material in the book.”

These two statements were distinctly categorized as “engaging with other learners” and “independent search for knowledge”. They represent two important learning processes associated with PBL. Despite these positive signs, most undergraduate feedback was negative and several categories: partiality towards didactic or directed learning, perception of reduced learning efficiency, and feelings of uncertainty, emerged.

B. Graduate course comparisons. Mean grades for graduate students in PBL and lecture format-class were $82.0 + 1.4\%$ and $82.5 + 2.2\%$, respectively. Grade distribution of the exams was similar between the two classes, with 26% versus 25% scoring in the 70's, 60% versus 75% scoring in the 80's, and 13% versus 0% scoring in the 90's in PBL and traditional lecture, respectively.

ANOVA of the graduate student grades showed no significant difference between the PBL and traditional lecture classes. Graduate level classes were smaller than undergraduate level classes. The traditional lecture class had no students earn a grade in the 90's (A range), six

students earn a grade in the 80's (B range) and 2 students earn a grade in the 70's (C range) compared to PBL where two students scored in the 90's nine scored in the 80's, and four scored in the 70's. Due to the low number of students, a chi square analysis could not be performed. Grade distributions in the graduate level classes are shown in Figure 2.

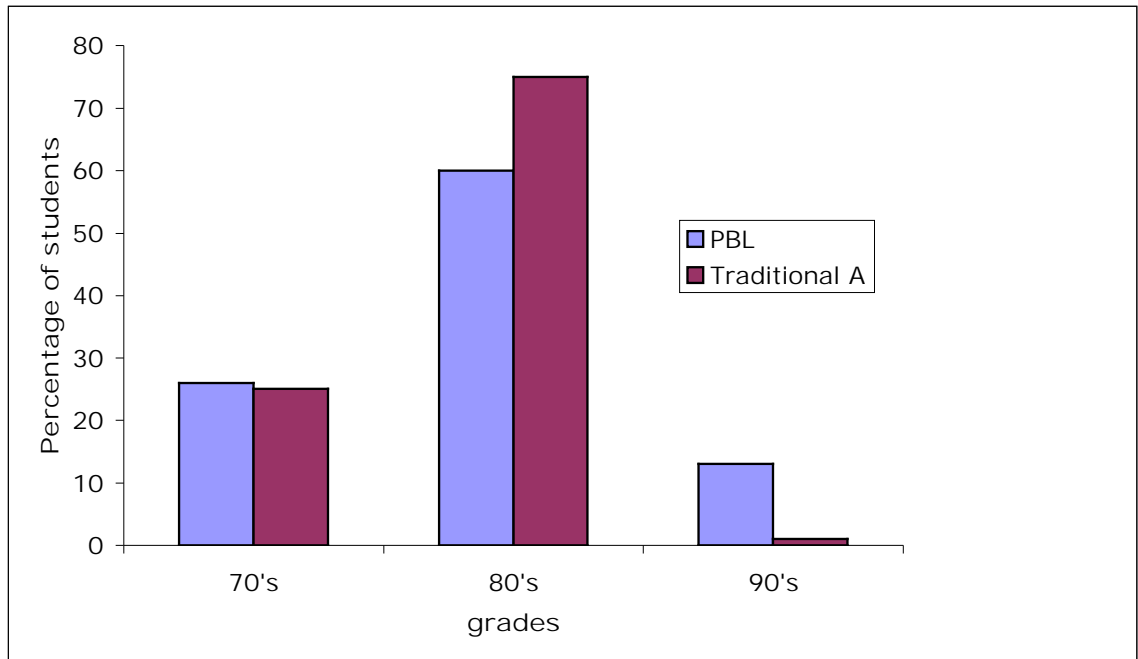


Figure 2. Grade Distributions in the Graduate Classes.

Negative feedback toward PBL was given by all but two graduate students. Graduate students specified no negative feedback toward traditional lecture-based learning. Graduate student feedback that was not supportive of PBL was sorted into the same three categories as undergraduate negative feedback: partiality towards didactic or directed learning, perception of reduced learning efficiency, and feelings of uncertainty. In the present study, both undergraduate and graduate students reported a remarkably similar undercurrent of dissatisfaction, frustration, and uncertainty that Biley's (1999) undergraduate nursing students and Seaberry's undergraduate chemistry students reported (Table 2).

IV. Discussion.

As an Academic Advisor who completes several dozen recommendations for professional and graduate school-bound students, I have noted the increasing number of programs that request information about student experiences in PBL. Many professional and graduate programs are grounded in PBL curricula. There are many reasons for this. Advocates of PBL believe that students learn better when they actively engage in solving real world problems instead of passively receiving information from the teacher to solve a problem. Deep learning can occur when students work together in small groups and in self-directed learning, where independent thinking is encouraged (Dahlgren & Dahlgren, 2002).

Studies on teaching and learning effectiveness have yielded mixed results comparing PBL with traditional lecture (Martin et al., 1998; Vernon & Blake, 1993). Despite the equivocal results, PBL, which has its roots in medical education in the 1970's, appears to be gaining favor

with many other types of professional schools including nursing, law, social work, pharmacy, clinical psychology, computer engineering, and physical and occupational therapy (Dahlgren & Dahlgren, 2002).

My first attempts in trying PBL in both undergraduate and graduate courses were prompted by the increased number of professional programs that currently implement PBL throughout the curricula and their desire for students with experience in PBL. Unfortunately, my first experiences in using PBL included perceptions of student frustration and vexation that I had not encountered before with traditional teaching. Despite student objections about the lack of learning they felt was occurring with PBL methods, I perceived that student discussions and knowledge acquisition was, in fact, happening. Nevertheless, I could not dismiss negative reactions and perceptions by students about their learning and so I decided to learn more about

Table 2. Similar student comments recorded by Biley (1999), Seaberry (2002), and Alessio.

Comments by Biley's students (1999)	Comments by Seaberry's students (2002)	Comments by Alessio's students
"It is so time consuming, there is such a large volume of knowledge to learn."	"It too way too much time."	"I think it would be effective if the teacher would go over essential information."
"I can see myself spending days in the library under piles of books...and having great difficulty getting any other work done."	"This method took around-about way to learn the concepts"	"Too much useless information."
"I like to be told things."	"You (the teachers) need to involve more of the class lecture material into the case work."	"I prefer getting the information straight from the professor than from working in small groups and learning from students."
"Lunging into completely unstructured sessions was frightening"	"It was hard to understand how it was supposed to work."	I did not like the PBL exercise. I felt lost and did not feel that I learned as well as if I were taught by lecture.
"There is such a lack of time and a lot of pressure to acquire knowledge."	"I need more explanation about how to work with the case material and the group itself."	Students seem to frantically compete for the right answer, talking over and around us less knowledgeable folks."

more about undergraduate and graduate student perceptions of and performance in classes in which PBL methods were used. All students were enrolled in college programs in which traditional teaching methods predominated. It was hypothesized that these students would experience tensions related to the transition from mainly didactic (teacher centered) to PBL (student centered) methods. Due to the novelty of PBL for virtually all students, it was also hypothesized that test performance may be inferior in students of PBL compared with traditional teaching methods. This hypothesis was not supported however, as test performance was similar between PBL and traditional teaching.

Two main positive themes about PBL emerged in this study.

- 1) Engaging with other learners, and
- 2) Independent work.

These two themes represent beneficial perspectives of PBL, but were clearly in the minority with only two students reporting positive comments related to working both independently and with others. The majority of feedback was negative towards PBL, and was categorized in three ways: 1. Preference for directive or didactic learning, 2. Perception of reduced learning efficiency, and 3. Feelings of uncertainty. Students stated that they preferred didactic learning, possibly because that was the main teaching method they had experienced prior to the present class. Students also contended that PBL took too much time compared to traditional lectures. Quinlan (2000) describes a literature database designed to address student concerns about making choices concerning resources and time management in order to guide veterinarian students towards the core material for learning. She found that the majority of veterinarian students preferred using their own database for gathering information, so in fact self-directed learning prevailed in these students.

Table 2 includes student feedback from two previous investigations and the current one on the use of PBL in the classroom. The critical statements were surprisingly similar in all three studies with time, information, learning style, and frustration emerging as significant issues for all students. Students in the present study complained that PBL left too much uncertainty to sort out pertinent information. These negative perceptions about PBL by students in this study did not differ from perceptions of PBL by students in other studies, where feelings of insecurity (Des Marchais et al., 1992), uncertainty (West, 1998), frustration, fear (Biley, 1999), reduced learning efficiency and confusion (Walton & Matthews, 1989) have been reported. Concerns expressed by students in the present study were not unique from previous studies, especially concerns related to grade-anxiety (Boud & Feletti, 1997).

In this study, mean grades did not differ in either undergraduate or graduate courses. In the undergraduate classes, the mean grades for traditional lecture classes (82.6 ± 1.6 and 80.8 ± 1.4) were indistinguishable from the mean for PBL (82.5 ± 1.3). A similar result occurred comparing graduate student grades in traditional lecture (mean = 82.5%) and PBL (82.0%). An analysis of grade distribution also showed that a similar percentage of students scored in the A, B, and C range regardless of the teaching method. These results indicate that neither PBL nor traditional lecture was superior in preparing students for testing. An important finding is that learning was not compromised by either teaching method.

In contrast to undergraduate and graduate students' perceptions that learning was somehow compromised via PBL activities, my perception of the classes was that the students were, in fact, engaging in active learning. As I listened to group discussions, I noted that students were asking each other questions that reflected deep learning and abstract thinking. Group interactions may have been facilitated in part by the "devil's advocate" role of one member in each group, whose job it was to raise critical questions when statements by other group members were made. Questions such as "Are you sure that information is accurate or up-to-date? Is there any evidence that would oppose that conclusion? What if...?" Seaberry (2002) reported similar teacher observations of face-to-face interactions and active discussions among the PBL student groups, during class time. I also observed students using resources other than the required text, to search for answers and information designed to fill in gaps and confirm statements made by group members. As I saw it, students in the small PBL groups engaged actively in the learning process and formed a type of learning community, with each making a meaningful contribution, as they tackled the problems. Student perceptions of their learning did not correspond with my

observations of in-class learning activities, nor did they predict test performance in either undergraduate or graduate students.

V. Conclusions.

A unique aspect of this study was that it focused on undergraduate and graduate students enrolled in liberal education classes, who unlike pre-professional and professional students are not usually accustomed to PBL. Nevertheless, many of these students aspire to enroll in academic programs such as medicine, social work, and law where PBL courses and entire curricula are widespread. Preparing students to cross the bridge from mainly teacher-centered to student-centered learning is important if they are going to succeed in academic programs in which PBL courses predominate. In the current study, negative feedback toward PBL was given by all but two undergraduate students, and was categorized as 1. Partiality towards didactic or directed learning, 2. Perceptions of reduced learning efficiency, and 3. Feelings of uncertainty. Similar results were obtained for graduate students with only two graduate students providing positive feedback about PBL, categorized as 1. Engaging with other learners, and 2. Independent work.

Nevertheless, PBL student test performances, analyzed by ANOVA and chi square analysis for both mean and grade distribution, were no different compared to students from classes in which information was presented by traditional lectures. In conclusion, despite negative student perceptions about learning in PBL classes, based upon student test performances, learning was not compromised in the PBL method. Based upon a combination of observation and questions, I judged the students to be actively engaged in the learning process. Results from the present study demonstrate a need to convince students that learning can and in fact, does occur despite a sense of discomfort by students in the PBL classroom. Furthermore, PBL curricula are ever-increasing in graduate and professional programs world-wide. Therefore, experiences in PBL during undergraduate studies can help to prepare students for success in graduate and professional program PBL curricula and careers in which problem solving takes place. Further research is necessary to learn about different ways in which PBL can be introduced and gradually implemented into both undergraduate and graduate curricula. A measured approach may address students' initial negative perceptions of PBL, while still providing meaningful student-centered learning experiences.

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