Scientific Research and Essay Vol.4 (8), pp. 753-762, August, 2009
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2009 Academic Journals

Full Length Research paper

A comparison of problem-based learning and traditional lecture students' expectations and course grades in an introductory physics classroom

Mehmet Sahin* and Nurettin Yorek

Department of Secondary Science and Mathematics Education, Dokuz Eylul University, 35160, Buca, Izmir, Turkey,

Accepted 13 July, 2009

The purpose of this study was to compare problem-based learning (PBL) and traditional lecture students' expectations about physics and physics learning and course grades in an introductory physics classroom. A total of 264 (PBL, n = 100; traditional, n = 164) freshman engineering students of Dokuz Eylul University (DEU) in Izmir, Turkey participated in the study. Student expectations were measured through the pre and post application of the Maryland Physics Expectations Survey (MPEX). Physics achievement data were obtained from students' end-of-semester physics grades. Data were analyzed using the analyses of variance (ANOVA), the repeated measure and multivariate analysis of variance (MANOVA) statistics. Results revealed that groups did not differ in their average MPEX scores as a result of one semester of instruction. Significant differences were determined in some components of the MPEX with respect to gender and instruction type. Overall, results of this study suggest that PBL approach has no positive influence on students' achievement in and expectations about physics and physics learning for this particular group of students. Implications of the results for physics education and further research are discussed.

Key words: Expectations, introductory physics, problem-based learning, MPEX

INTRODUCTION

Students' expectations about learning and science knowledge have been emphasized in the literature because of its importance for the learning of science (Prosser, Walker, and Millar, 1996; Radloff and De La Harpe, 2001; Redish, Saul, and Steinberg, 1998). Expectations are beliefs about the learning process and the structure of knowledge (Mistades, 2007). It has been well established that students come to physics classes with a view that might be very different from instructors' beliefs. These beliefs have been shown to affect how students learn and what they want to learn. Helping students attain more expert-like beliefs can foster their learning. To do this, researchers have developed a series of instructional approaches. One of them is problem-based learning which has been used widely throughout the world and has been in some cases shown to enhance students' social skills, motivation, and interest in the subject matter.

Problem-based learning

Problem-based learning (PBL) has been employed in medical schools for a long time (Barrows and Tamblyn, 1980). It has gained prominence as a way of instruction in various disciplines including medicine, engineering, and education among others (Edens, 2000; Edwards and Hammer, 2004; Eldredge, 2004; Fink et al., 2002; Jones, 2006; Kwan, 2000; Saarinen-Rahiika and Binkley, 1998; Stonyer and Marshall, 2002). PBL was not a popular mode of instruction in physics until last decade or so (Sahin, 2007, 2009; Duch, 1995, 1996; Raine and Collett, 2003).

The definition of PBL varies widely due to differences in practice and has appeared in various review papers such as Gijbels et al. (2005) and Prince (2004). It is not intend of this paper to cover the history of PBL, however, it may be useful for the reader to mention some basic features of PBL here. The key characteristic of PBL,

---

*Corresponding author. E-mail: mehmet.sahin@deu.edu.tr, mehmet.sahince@gmail.com. Tel.: +90.232.420.4882/1338. Fax: +90.232.420.4895.

according to Gijbels et al. (2005) is posing a 'complex problem' to students to initiate the learning process. Torp and Sage (2002) described PBL as focused, experiential learning organized around the investigation and resolution of messy, real-world problems. They describe students as engaged problem solvers, seeking to identify the root problem and the conditions needed for a complete solution and in the process becoming self-directed learners. Rhem (1998) suggests a PBL definition that emphasizes meaning-making over fact-collecting. PBL is generally implemented as a small group tutorial in which students work through scenarios. The scenarios provide the context for learning; involve ill-structured, interesting, open-ended, and real-life problems to motivate students and stimulate discussion (Levin, 2001).

Research conducted on the effectiveness of PBL has been mostly in the field of medicine as evidenced in several comprehensive reviews of literature (Albanese and Mitchell, 1993; Berkson, 1993; Colliver, 2000; Major and Palmer, 2001; Norman and Schmidt, 1992, 2000; Prince, 2004; Vernon and Blake, 1993). Despite a general agreement on the definition of PBL, the approach varies greatly in application. The large variation in PBL practices makes the evaluation of its effectiveness difficult. Researchers who have investigated PBL in medical schools have reached contradictory conclusions. For example, Albanese and Mitchell (1993) concluded that problem-based instructional approaches were less effective in teaching basic science, whereas Vernon and Blake (1993) reported that PBL approaches were more effective in generating student interest, sustaining motivation, and preparing students for clinical interactions with patients. Moust, Van Berkel and Schmidt (2005) noted that research into PBL has shown that PBL has a positive effect on the process of learning as well as on learning outcomes. Prince (2004) in his review of action learning suggests that it is difficult to conclude if it is better or worse than traditional curricula, and that 'it is generally accepted … that PBL produces positive student attitudes' (p. 228). Major and Palmer (2001) agree with Prince and conclude their review of PBL literature by stating 'students in PBL courses often report greater satisfaction with their experiences than non-PBL students' (p. 4). However, a study by Beers (2005) demonstrated no advantage in the use of PBL over more traditional approaches. In an experimental study designed to investigate the effectiveness of PBL among first-year students in the college of science at a university in Peru, Alcázar and Fitzgerald (2005) found that students in the PBL sections obtained statistically significant higher scores in the post-test for the item measuring higher order thinking skills than students in the non-PBL sections.

There are very few studies on the effectiveness of PBL in physics education (Akınoğlu and Tandoğan, 2007). A study conducted to determine the effects of problem-based active learning in science education on seventh grade students' academic achievement and concept learning found that the implementation of problem-based active learning model had positively affected students' academic achievement and their attitudes towards the science course. It was also found that the application of problem-based active learning model affected students' conceptual development positively. Sahin (2007) discusses the factors that may have roles in the efficiency of PBL approach such as group work, integration of disciplines, and the role of instructor and suggests researches to investigate the effects of these factors. Sahin (accepted for publication) has reported the results of an exploratory study on expectations of university students about physics and physics learning in a PBL class. Results of the study revealed that students' expectations deteriorated rather than to improve as a result of one semester of instruction.

The literature on the efficacy of PBL suggests conflicting views; as Prince (2004) remarks, we need further research evidence to better understand what works and support or reject the view that PBL is better, and in what way(s) than traditional methods. Therefore, with the hope to contribute to physics education and PBL literature, this study aims to determine the expectations of students enrolled in an introductory physics course utilizing problem-based learning approach and compare these to that of students enrolled in a traditional introductory physics course. In addition, this study has compared both group students' physics performance which was measured via course grades.

Expectations about physics

The phrase *expectation* was used (Redish et al., 1998) to represent students' prior conceptions, attitudes, beliefs, and assumptions about what sorts of things they will learn, what skills will be required, and what they will be expected to do in addition to their view of the nature of scientific information in a physics classroom. The study by Redish et al. (1998) has focused on "students' expectations about their understanding of the process of learning physics and the structure of physics knowledge" (p. 213). The term *expectation* was used in the same meaning in the present study.

Instructors in science courses may have implicit expectations about what students should learn and how to learn it (Lin, 1982). Redish et al. (1998) refer to these goals as the "hidden curriculum." It has been shown that students come to physics classes with a variety of goals and expectations about physics and physics learning most of which are very different from that of an expert's beliefs. As Hammer (1994) reports, some students consider physics as weakly connected pieces of information to be learned separately, whereas others see physics as a coherent set of ideas to be learned together. Some students perceive learning physics as memorizing formulas and problem solving algorithms, while others think that learning involves developing a deeper conceptual understanding. Some students believe that physics is not connected to the real world, while others believe that ideas learned in physics are relevant and useful in a wide variety of real contexts. Researchers who investigated students' expectations and their role in physics learning have reported that students' expectations have effects on how they study, how they learn, and what they want to learn (e.g., Hogan, 1999; Lederman, 1992; McDermott and Redish, 1999 and the references therein).

Studies by Carey et al. (1989) and Songer and Linn (1991) have indicated that many pre-college students have misconceptions both about science and about what they should be doing in a science class. For example, Songer and Linn (1991) studied students in middle schools and determined that they could categorize students as having beliefs about science that were either *dynamic* (science is understandable, interpretive, and integrated) or *static* (science knowledge is memorization-intensive, fixed, and not relevant to their everyday lives). In describing high school students' assumptions about mathematics learning, Schoenfeld (1992) concluded that student's beliefs shape their behavior in ways that have extremely powerful (and often negative) consequences. Halloun and Hestenes (1985) suggested that the more consistent the students' and instructors' views about learning physics were, the better these students performed in the course.

The literature emphasizes that expectations are important in how students make sense of their world and their learning. If inappropriate expectations play a role in students' common difficulties with introductory calculus-based physics, they need to be tracked and documented in order to help students improve their expectations which may in turn increase their success and enrollment in introductory physics classes. There are only a few researchers who studied student beliefs in the field of introductory physics (Author, 2009; Elby, 2001; Hammer, 1989, 1994, 1995; Roth and Roychoudhury, 1994; Redish et al., 1998). Except for several studies which reported gains on the MPEX (e.g., Elby, 2001; Marx and Cummings, 2007), studies in this area generally reported deteriorating post MPEX scores (e.g., Redish et al., 1998; Ornek et al., 2008). Author (2009) has investigated the correlations of PBL and traditional students' course grades, expectations and beliefs about physics and selected student variables in an introductory physics course in engineering faculty. Students' expectations and beliefs about the kind of activities and work necessary to make sense out of physics were found to be related to their physics grades.

A common way of measuring students' views, expectations, and beliefs about physics and science is to use surveys (Kortemeyer, 2007). Some of the most commonly found surveys in the literature are, the Views about Science Survey (VASS) (Halloun, 1997), the Maryland Physics Expectations Survey (MPEX) (Redish et al., 1998), the Epistemological Beliefs Assessment Survey (EBAPS) (Elby et al., 1997), and the Colorado Learning Attitudes about Science Survey (CLASS) (Adams et al., 2004). The present study has employed the MPEX as the instrument to measure students' expectations.

The Maryland physics expectations survey (MPEX)

The MPEX developed by Redish et al. (1998) is a widely used scale primarily intended to evaluate the impact of one or more semesters of instruction on an overall class. The MPEX consists of a variety of statements about the nature of physics, the study of physics and students' relation to them. It has 34 items rated on a five-point Likert-scale from strongly disagree (1) to strongly agree (5). Items for the survey were chosen as a result of a detailed literature review, discussions with physics faculty, and Redish and his colleagues' (1998) combined 35 years of teaching experience. The items were then validated in a number of ways: by discussion with other faculty and physics education experts, through student interviews, by giving the survey to a variety of "experts," and through repeated delivery of the survey to groups of students. The authors defined "expert" as the response that was given by a majority of experienced physics instructors who have a high concern for educational issues and a high sensitivity to students. The authors of the survey referred to the extreme view that agrees with that of most expert scientists as the 'expert' or 'favorable' view, and the view that agrees with that of most novice students as the 'novice' or 'unfavorable' view. In addition, the collection of survey items designed to probe a particular dimension was referred to as a *cluster*.

The MPEX focuses on six clusters (dimensions or factors) along which to categorize student attitudes toward the appropriate way to study physics: Beliefs about learning physics (*Independence*), beliefs about the content of physics knowledge (*Concepts*), beliefs about the structure of physics knowledge (*Coherence*), beliefs about the connection between physics and reality (*Reality Link*), beliefs about the role of mathematics in learning physics (*Math Link*), and beliefs about the kind of activities and work necessary to make sense out of physics (*Effort*). The italics indicate the MPEX clusters.

MATERIALS AND METHODS

This is a descriptive/comparative study aimed to determine and compare university students' expectations in a calculus-based introductory physics course utilizing PBL and traditional lecture approaches. In addition, the study has compared students' physics performance and background variables, such as gender. Students' physics performance was determined from students' final raw percentage scores not from the letter grades, since raw scores provide finer grained information about the overall student performance in the course (Kortemeyer, 2007).

Sample

The study involved 264 students at their second semester of a

Table 1. Distribution of the sample according to gender and instruction type.

	PBL Group		Traditional Group		
Gender	***n***	**%**	***n***	**%**	**Total**
Female	30	30	46	28	76
Male	70	70	118	72	188
Total	100	100	164	100	264

calculus-based introductory physics course at DEU (Table 1). There were 100 students in the PBL group and 164 students in the traditional group. The PBL group students ranged in age from 19 - 23 years, with an overall mean age of 20.6 (SD = 1.32). Traditional group students ranged in age from 19 - 23 years, with an overall mean age of 20.4 (SD = 1.18). The sample of this study was a convenient sample. They were selected by virtue of being the students in the school where the researcher worked (Sander et al., 2000). Students in the departments of electrical and electronics, geological, and geophysics engineering are instructed through PBL approach. The civil, environmental, and computer engineering departments utilized traditional lecture method.

The modified MPEX

For the purpose of this study, the MPEX was modified and translated into Turkish, and was examined by physics education and Turkish language experts in terms of appropriateness of wording to validate the survey for use with this particular sample. The author paid special attention and worked with physics education and Turkish language experts to maintain the meaning of the originnal items during the translation of the MPEX into Turkish. The items and the structure of the survey were maintained. A factor analysis conducted on the data obtained confirmed the original clusters, yielding a Cronbach alpha value for the overall instrument as 0.74. Reliability values for the six clusters ranged from 0.68 to 0.81. Beginning and end of semester scores were calculated for participating students. The same analysis was done for each cluster of the MPEX for which sample items are given below (Redish, et al., 1998):

(1) Independence. Unfavorable: In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as given.
(2) Coherence. Unfavorable: Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.
(3) Concepts. Favorable: When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.
(4) Reality link. Unfavorable: Physical laws have little relation to what I experience in the real world.
(5) Math link. Unfavorable: All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.
(6) Effort. Favorable: I go over my class notes carefully to prepare for tests in this course.

Problem-based learning at Dokuz Eylul University (DEU)

It is important to describe the application of PBL in detail to help the reader evaluate the effectiveness of PBL in this study. Since the literature has shown that it is difficult to determine the effectiveness of PBL due to wide a variety of practice, to provide some detailed information about the application process in this study would help to understand what is being studied and what works.

Several departments of DEU have replaced its traditional curriculum program with a modular PBL approach starting with the freshman class in Fall, 2002. PBL curriculum is supposed to motivate, improve students' creative thinking skills, and enable them to interact with peers, faculty, and the subject matter and hence positively influence student learning.

Modules are basically scenarios within which concepts are presented in a real-life problem. First year modules are integrated scenarios including concepts from physics, mathematics, and sometimes from basic engineering, materials, and/or chemistry courses. PBL sessions aimed at the discussion of problems constructed in a scenario-like context by the students were formed into groups of eight. The process usually takes place as the following:

The tutor distributes copies of the first part of the scenario to the group. Students read aloud the context of the problem, define the problem, produce hypotheses, and discuss them in the light of the new information provided in the next section of the scenario, and disregard false hypotheses thus forming a hypothesis toward the solution of the problem. Students determine the concepts which they need to study and learn mostly in the first session as a kind of a learning objective emerging from that session. The process takes two or three PBL sessions until an agreement about the solution of the problem is reached.

A module includes a laboratory section that differs from traditional labs. Groups of 5 - 6 students carry out PBL labs (physics or electronics). There is one lab assistant per two groups. There is no lab manual in the PBL labs, students are provided with a brief description sheet about the experiment.

In addition, PBL program has a project part. Groups formed by 5-6 students work together throughout the semester to plan, design, implement, and report a project. During the process students are monitored, guided, encouraged, and evaluated via weekly consultations by the instructors. At the end of the semester, students present their projects in the form of posters and hand in a final report.

There is an evaluation test (exam) at the end of each module. Students' end-of-module exam scores, PBL session scores, and lab and project scores are averaged and they are given a final score. Students who scored 70 or above are considered successful and students who scored below 70 are considered unsuccessful and need to repeat the module and hence the whole year.

Data collection and analyses

Data were collected via the pre and post application of the MPEX to 264 freshmen engineering students of Dokuz Eylul University during the second semester of 2006 - 2007 academic years. To obtain matched pre-post data, only those students who took MPEX as both a pre- and a post-assessment (n = 264) were included.

The Traditional group physics grades were calculated from homework, two midterms, and a final exam. In this study, only students' final grades were available as a measure of their physics understanding and used as the dependent variable. All engineering students at DEU have very similar scores on university entrance examination. Therefore, all students were regarded as having similar science and mathematics background based on their similar scores on the university entrance examination. Both groups were taught by the same physics instructor and thus both groups were tested using the same tests in all exams. Structure of the courses and the number of students in both groups are presented in Table 2.

Data were analyzed using SPSS 13.0 statistical analysis program. Means and standard deviations were calculated and analysis

Table 2. Characteristics of the groups of study.

Institution	Instructional Characteristics	*n*
DEU PBL group	(Modular) Problem-based active learning, with group learning PBL sessions, traditional presentations, labs, and small projects	100
DEU Traditional group	Traditional lectures and recitations with no labs	164

Table 3. Percentage of students' favorable/unfavorable responses on overall and clusters of the MPEX.

	Overall	Ind.	Coh.	Con.	Reality	Math	Effort	*n*
Experts	87/6	93/3	85/12	89/6	93/3	92/4	85/4	
DEU PBL pre	47/30	35/39	37/37	39/38	65/17	46/29	55/21	100
post	38/33	29/43	25/44	37/30	51/20	35/34	47/23	
DEU trad. pre	44/32	34/41	38/37	39/36	53/21	45/32	51/26	164
post	38/35	31/41	31/40	38/36	45/28	38/32	47/28	

Note. Ind.: Independence; Coh: Coherence; Con.: Concepts; Reality: Reality link; Math: Math link.

of variance (ANOVA), repeated measure analysis of variance, and multivariate analysis of variance (MANOVA) were conducted to compare the students of both groups. Partial η^2 (eta square) statistics and the Time x Group interaction effect were examined to determine the effect of PBL. Multivariate analysis helps control for intercorrelations among variables (Tabachnick and Fidell, 2001) and is considered the more statistically powerful technique in the context of repeated measures experiments. Partial η^2 are recommend as a measure of accounted for variance, either in an ANOVA or in a MANOVA (Tabachnick and Fidell, 2001). It is equivalent to a squared partial correlation (Levine and Hullett, 2002). The Time x Group interaction estimates the treatment effect in a repeated measures analysis of pre- and posttreatment data and is equivalent to a one-way ANOVA of difference scores (Bonate, 2000).

The results are presented by specifying the percentage of favorable responses. A 'favorable' response is defined as a response in agreement with the expert response and an 'unfavorable' response is defined as a response in disagreement with the expert response. Agree and strongly agree responses (4 and 5) were added together and disagree and strongly disagree responses (1 and 2) were added together. Table 3 displays students' MPEX percentage scores in the form of favorable/ unfavorable in each cluster and overall. The percentage of neutrals and not answering can be obtained by subtracting the sum of the favorable and unfavorable responses from 100.

RESULTS AND DISCUSSION

The initial state of the PBL and the traditional students at DEU differs substantially from the expert responses as indicated in Table 3. The PBL students agreed with the favorable (expert) responses about 35 - 65% of the time in the first deployment, 25 - 51% of the time in the post deployment and the traditional students agreed with the favorable responses about 34 - 53% of the time in the first deployment, and 31 - 47% of the time in the post deployment in the clusters of the MPEX. All DEU students' expectations deteriorated as a result of one semester of instruction, whether in the PBL or traditional classes.

Overall, all DEU students showed lower favorable expectations and higher unfavorable expectations than other university students (Ornek et al., 2008; Redish et al., 1998). It was reported that students' overall expectation scores deteriorate rather than improve between the beginning and end of a course, even at universities and colleges employing research-based curricular approaches which were shown to result significantly better conceptual learning than traditional curricula do, as measured by the FCI and other evaluation instruments (Hake, 1998). Hence, it may be concluded that these results suggest that students can involve in effective learning without changing their views and beliefs regarding the nature of learning and knowledge (Lising and Elby, 2005).

To determine whether the PBL group mean favorable scores differed from that of the traditional group and to determine if the students' favorable means were different with respect to course grade, analyses of variance were conducted. Descriptive statistics such as mean (*M*) and standard deviation (SD) were determined for all variables. All analyses were conducted at a significance level of alpha = 0.05. In the data the groups have different sample sizes. This may have influence the group variances. The ANOVA assumes that groups are normally distributed with equal variances, though it is robust upon departures from these conditions. The results of ANOVA were confirmed with Welch's test, which identifies differences between groups and does not require equal variances. In all cases, Welch's test agreed with the results of ANOVA. Table 4 presents means and standard deviations by group for the overall average favorable percent scores on the pre and post application of the MPEX.

Table 4. Pre- and post application means and standard deviations for PBL and traditional groups on overall MPEX.

Measure	**PBL, *n* = 100**		**Traditional, *n* = 164**	
Overall percent favorable score	***M***	***SD***	***M***	***SD***
Pre	47.33	13.37	43.94	15.59
Post	38.13	14.88	38.14	13.77

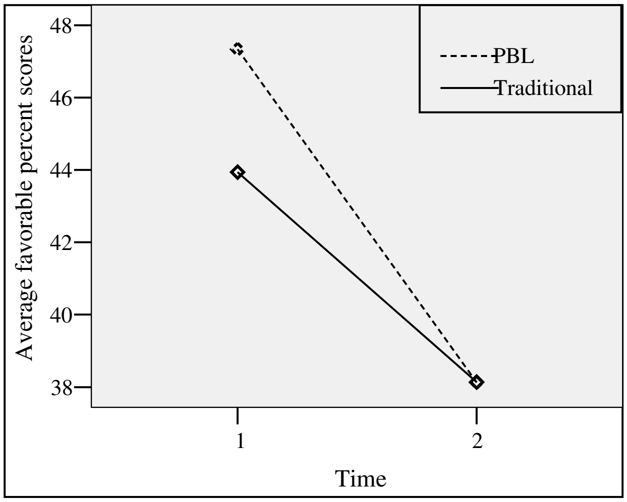

Figure 1. Pre- and post average favorable percent scores for PBL and traditional groups.

Results indicated a non-significant main effect for group ($F_{[1, 262]}$ = 1.53, p = 0.22, partial η^2 = 0.006), for overall percent favorable score as a multivariate composite. Univariate ANOVA indicated that PBL and traditional groups did not differ in their overall average favorable percent scores across pre- and post administration of the MPEX. Results from 2 (group) x 2 (time) repeated measure analysis of variance yielded a significant main effect for time ($F_{[1, 262]}$ = 36.97, p = 0.000, partial η^2 = 0.124) suggesting that average favorable percent scores for both groups decreased from pre to post administration (Table 4). However, the lack of a significant Time x Group interaction ($F_{[1, 262]}$ = 1.90, p = 0.169, partial η^2 = 0.007) suggested no between-group differences in the pre to post administration change in overall average favorable percent scores. Figure 1 shows the mean pre- to post application change per group across time on the overall MPEX.

Since the groups did not differ in their overall MPEX scores, further analyses were conducted to see whether the scores of groups would differ on any cluster of the MPEX. A MANOVA revealed that PBL and traditional groups did not differ in their pre-scores on all the MPEX clusters except for reality link cluster ($F_{[1, 262]}$ = 11.46, p = 0.001, partial η^2 = 0.042) on which the PBL students (M = 65) had significantly higher average pre-scores than the traditional students (M = 53).

The MANOVA results also revealed that the groups did not differ in their post-scores on all the MPEX clusters except for coherence cluster ($F_{[1, 262]}$ = 5.70, p = 0.018, partial η^2 = 0.021) on which traditional students (M = 31) had significantly higher average post-scores than PBL students (M = 25). Thus the results suggest that groups did not differ in their coherence cluster scores at the beginning but they differ in that at the end of the semester. In addition, groups differed in their reality link cluster score at the beginning but they were not different in that at the end of the semester. It would be more informative to look at the changes in both groups' cluster scores from pre to post administration and compare the groups with respect to these changes.

Results indicated a non-significant main effect for group, for independence ($F_{[1, 262]}$ = 0.40, p = 0.528, partial η^2 = 0.002), coherence ($F_{[1, 262]}$ = 3.19, p = 0.075, partial η^2 = 0.012), concepts ($F_{[1, 262]}$ = 0.12, p = 0.725, partial η^2 = 0.000), math link ($F_{[1, 262]}$ = 0.26, p = 0.608, partial η^2 = 0.001), and effort clusters ($F_{[1, 262]}$ = 0.74, p = 0.392, partial η^2 = 0.003) and a statistically significant main effect for group, for reality link ($F_{[1, 262]}$ = 11.68, p = 0.001, partial η^2 = 0.043) for percent favorable scores on these clusters as multivariate composite.

The repeated measures MANOVA indicated that PBL and traditional groups did not differ in their average favorable percent scores on independence, coherence, concepts, math link, and effort clusters across pre- and post administration of the MPEX. Univariate ANOVA also indicated that the PBL group had higher average favorable percent score on reality link cluster than did the traditional group across pre- and post administration (Table 3).

Results of a 2 (group) x 2 (time) repeated measures MANOVA yielded a statistically significant main effect for time for independence ($F_{[1, 262]}$ = 5.91, p = 0.016, partial η^2 = 0.022), for coherence ($F_{[1, 262]}$ = 23.62, p = 0.000, partial η^2 = 0.083), reality link ($F_{[1, 262]}$ = 19.31, p = 0.000, partial η^2 = 0.069), math link ($F_{[1, 262]}$ = 18.81, p = 0.000, partial η^2 = 0.067), and effort ($F_{[1, 262]}$ = 8.36, p = 0.004, partial η^2 = 0.031) clusters and a non-significant main effect for time for concepts ($F_{[1, 262]}$ = 0.38, p = 0.539, partial η^2 = 0.001) cluster. The statistically significant main effect for time for the former clusters suggests that scores for both groups decreased from Time 1 (pre) to Time 2 (post), however, a non-significant main effect for

Table 5. Pre- and post application means and standard deviations for PBL and traditional groups on overall MPEX according to gender.

Group	Gender	Average favorable percent scores M Pre	M Post	SD Pre	SD Post	n
PBL	Female	50	37	13.36	12.97	30
	Male	46	39	13.35	15.68	70
Traditional	Female	42	37	17.45	13.47	46
	Male	45	38	14.84	13.92	118
Total	Female	45	37	16.26	13.19	76
	Male	45	39	14.29	14.56	188
	Total	45	38	14.85	14.17	264

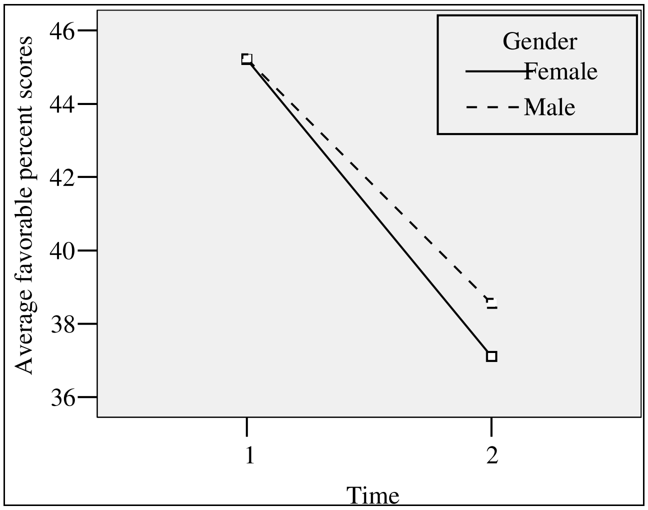

Figure 2. Pre- and post average favorable percent scores for females and males.

time for concepts cluster suggests that scores for both groups did not change from Time 1 to Time 2 (Table 3).

The Time x Group interaction was not significant for any of the clusters, which suggested relative stability in the magnitude of favorable percent-score differences between PBL and traditional groups. To determined whether gender was a significant factor in the students' expectations and in the change in those expectations, a series of univariate and repeated measure analyses of variance were conducted using the gender as the between subjects factor. Table 5 presents means and standard deviations by group for the overall average favorable percent scores on pre and post application of the MPEX according to gender.

Univariate ANOVA analyses revealed that males (M = 45) and females (M = 45) did not differ in their pre ($F_{[1, 262]}$ = 0.00, p = 0.993, partial η^2 = 0.000) and post scores ($F_{[1, 262]}$ = 0.56, p = 0.453, partial η^2 = 0.002) on overall MPEX. A repeated measures ANOVA revealed a non-significant main effect for gender ($F_{[1, 262]}$ = 0.25, p = 0.617, partial η^2 = 0.001) for the percent favorable score as multivariate composite, indicating that that males and females did not differ in their average favorable percent scores on overall MPEX across pre- and post administration.

Results from the 2 (gender) x 2 (time) repeated measure analyses of variance yielded a statistically significant main effect for time ($F_{[1, 262]}$ = 31.09, p = 0.000, partial η^2 = 0.106). This suggests that average favorable percent scores for males and females have dropped from pre to post administration (Table 5). However, the lack of a significant Time x Gender interaction ($F_{[1, 262]}$ = 1.90, p = 0.169, partial η^2 = 0.007) suggested no gender differences in pre to post administration change in overall average favorable percent scores. Figure 2 shows the mean pre- to post application change for gender across time on the overall MPEX.

In this study students' physics learning was measured by their end-of-semester course grades. Although this score alone may not be enough to represent student learning, it still gives some insight into students' physics knowledge measured by tests, exams, and homework prepared by the instructors. A similar approach was used elsewhere (Kortemeyer, 2007). Means and standard deviations for PBL and traditional group physics end-of-semester grades are presented in Table 6.

The Univariate ANOVA results indicated that traditional students (M = 71.41) had significantly higher average physics grades than PBL students (M = 64.97). This result should be evaluated keeping in mind that the difference may have been occurred due to simply by chance, or to some student related factors such as lack of interest and motivation in and toward PBL, or because of instructtional contexts. In addition, since there is no other premeasure of students' physics achievement other than the university entrance examination scores (which are very similar for the participants of this study), the change from pre to post measurement might not be significant as well.

The Univariate ANOVA results indicated gender differences for traditional lecture method. No significant gender difference was found for PBL approach. Average

Table 6. PBL and traditional group end-of- semester mean physics grades.

Group	Gender	Physics grades		
		M	SD	n
PBL	Female	67.27	9.01	30
	Male	63.99	12.62	70
	Total	64.97	11.71	100
Traditional	Female	75.22	10.31	46
	Male	69.92	12.02	118
	Total	71.41	11.78	164

physics grades of females were higher than that of males, however, the difference was not significant. Males and females in the PBL group had similar end-of-semester physics grades ($F_{[1, 98]} = 1.66$, p = 0.201, partial $\eta^2 = 0.017$), whereas females had significantly higher physics grades than did males in the traditional group ($F_{[1, 262]} = 6.93$, p = 0.009, partial $\eta^2 = 0.041$). Caution should be advised in generalizing this finding since the number of females was significantly lower than males in both groups. Hence, gender effect in physics grade and instruction type might have occurred simply by chance. Of course, there can be a gender effect as well and in this particular study, females might have obtained higher physics grades than did males.

Conclusion

The purpose of this study was to investigate university students' achievement in and expectations about physics in an introductory calculus-based physics course utilizing different instructional techniques. The study has compared achievement and expectations of PBL and traditional group students in a physics class. In addition, relationships of student expectations, achievement, and gender were examined. The overall scores (that is, percent agreement with the expert group) of PBL (overall 38%) and traditional students (overall 38%) on the MPEX clusters were very low compared to expert scores. The students' expectations about physics were found to deteriorate rather then improve after one semester of instruction.

Decreases in both groups' favorable scores were statistically significant for the overall MPEX. The PBL group had higher average favorable percent score on reality link cluster than did traditional group across pre- and post administration. Comparisons of the PBL and traditional group students' pre- and post scores revealed that the groups did not differ in their overall favorable scores at the beginning of the semester and also at the end of the semester groups did not differ in their overall favorable scores. The results suggest that PBL was no different than traditional instruction in influencing students' achievement in and expectations about physics.

One of the possible explanations of low scores of both groups might be the students' negative feelings about physics and the course at the beginning of the semester, and the fact that they thought they could not do physics, and perhaps the most important was that they had grade concerns. The PBL group was more concerned about their grades because to be successful they require a total final grade of 70 out of 100. The traditional group students require a total of 60 out 100 to pass the course. It is thought that grade concern puts a considerable pressure on the PBL group students since as observed by the author. In addition to grade concerns, it is thought that heavy course loads of the PBL students might have influenced their expectations and beliefs about the course. The PBL students had very limited free time for individual studies. They spent a great deal of effort and time on the project which constituted only 5% of their final grade.

Gender was found to be a significant factor in several clusters. Males and females in both groups did not differ in their favorable scores on overall MPEX. Decreases in pre- and post-scores of males and females in both groups were statistically significant.

Favorable scores of both groups in this study were relatively lower than that of other universities reported in the literature. Deteriorating results were also reported in other studies (Ornek et al., 2008; Redish et al., 1998).

There were limitations of this study, such as not being able to identify groups randomly and control variables. Perhaps the most significant limiting factor in this study was that PBL approach might have led students to feel anxious and also caused grade concerns. The PBL students' weekly schedule was very busy and this might have caused them to get bored with the approach. In fact, in personal communications, they complained about PBL approach frequently to the author. Therefore, it can be said that the findings of this study are not conclusive enough to make any generalizations, however, the findings still show some relationships between variables, might be context dependent though, which suggest further more controlled studies. The reader should be reminded that new and innovative approaches such as PBL are new to Turkish students, and a sudden and complete change in instructional techniques can be difficult for them to adapt immediately in the freshman year.

IMPLICATIONS FOR INSTRUCTION AND FUTURE RESEARCH

The influences of beliefs and expectations on student learning have been documented in the literature for more than two decades. It is important to better understand the relationships of expectations with learning. Despite several limitations, this study has been able to add to the literature in this area.

The results of this study suggest the need for using more controlled research contexts in order to determine the combined effects of variables on students' expectations and achievement. In addition, different research methods could be employed to gain more insight into students' expectations and beliefs, such as qualitative research methods (e.g., interviews, open-ended written questionnaire) though these could take more time than quantitative approaches.

The relationships of students' expectations and variables found in some clusters of the MPEX may suggest that students' expectations should be taken into consideration when planning instruction.

Students' beliefs about learning physics and the kinds of activities and work necessary to make sense out of physics may change with gender. Results of the study suggest that gender may be further investigated to determine the possible contributions of female and male students' expectations to their success.

In this study, students exhibited very low agreement to expert views in all clusters of the MPEX. This would probably affect their attitudes, study habits, motivation, and thus their success in the course. If we want our students to start to change their view of learning from a novice view of learning to a more sophisticated and expert-like set of attitudes in physics classes we need to pay special attention to their beliefs and expectations when they come to university classes. Future studies therefore may focus on creating open instructional environments that will enable students develop more expert-like beliefs and expectations about physics.

REFERENCES

Adams WK, Perkins KK, Dubson M, Finkelstein ND, Wieman CE (2004). The design and validation of the Colorado learning attitudes about science survey. Retrieved August 25, 2008, from http://phet.colorado.edu/phet-dist/publications/Adams-PERC-2004.pdf.

Akınoğlu O, Tandoğan RO (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. Eurasia J. Math. Sci. Technol. Edu. *3*(1): 71-81.

Albanese MA, Mitchell S (1993). Problem-based learning: a review of the literature on its outcomes and implementation issues. Acad. Med. 68: 52-81.

Alcázar MTM, Fitzgerald VL (2005). An experimental design to study the effectiveness of PBL in higher education, in first year science students at a university in Peru, South America. *College Quarterly*, 8 (2). Retrievedon 03/22/2009 from http://www.senecac.on.ca/quarterly/2005-vol08-num02-.spring/alcazar_fitzgerald.html.

Barrows HS, Tamblyn RM (1980). Problem-based learning: An approach to medical education. New York: Springer.

Beers G (2005). The effect of teaching method on objective test scores: problem based learning versus lecture. J. Nurs. Edu. 44(7): 305-309.

Berkson J (1993). Problem-based learning: Have the expectations been met? Invited review. Acad. Med. 10: 79-88.

Bonate PL (2000). Analysis of pretest-posttest designs. New York: Chapman & Hall/CRC.

Carey S, Evans R, Honda M, Jay E, Unger C (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. Int. J. Sci. Edu. 11: 514-529.

Colliver JA (2000). Effectiveness of problem-based learning curricula: Research and theory. Acad. Med. 75: 259-266.

Duch B (1995). Problem based learning in physics: The power of students teaching students. About Teaching, 47, 6-7. Retrieved on August 13 2008 from http://www.udel.edu/pbl/cte/jan95-phys.html.

Duch B (1996). Problem-based learning in physics: The power of students teaching students. J. Coll. Sci. Teach. 26: 529-541.

Edens K (2000). Preparing problem solvers for the 21st century through problem based learning. Coll. Teach. 48(2): 55-60.

Edwards S, Hammer M (2004). Teacher education and problem-based learning: Exploring the issues and identifying the benefits. Paper presented at the International Education Research Conference of the Australian Association for Research in Education, Melbourne, Victoria, Australia.

Elby A (2001). Helping physics students learn about learning. Physics Education Research, Am. J. Phy. Suppl. 69(7): S54-S64.

Elby A, Frederiksen J, Schwarz C, White B (1997). EBAPS: epistemological beliefs assessment for physical sciences. Paper presented at the Annual Conference of the American Educational Research Association, March 24-28, in Chicago.

Eldredge JD (2004). The librarian as tutor/facilitator in a problem-based learning (PBL) curriculum. Reference Services Review 30(4): 355-358.

Fink FK, Enemark S, Moesby E (2002). Centre for problem-based learning (UCPBL) at Aalborg University. Paper presented at the 6th Baltic Region Seminar on Engineering Education, Wismar, Germany.

Gijbels D, Dochy F, Van Den Bossche P, Segers M (2005). Effects of problem based learning: A meta-analysis from the angle of assessment. Rev. Edu. Res. 75(1): 27-61.

Hake RR (1998). Interactive-engagement vs. traditional methods: A six-thousand- student survey of mechanics test data for introductory physics. Am. J. Phy. 66(1): 64-74.

Halloun I (1997). Views about science and physics achievement: The VASS story. In E.F. Redish & J.S. Rigden (Eds.), The changing role of physics departments in modern universities. Proceedings of ICUPE. College Park, Maryland: American Institute of Physics Press pp. 605-613.

Halloun IA, Hestenes D (1985). The initial knowledge state of college physics students. Am. J. Phy. 53(11): 1043-1056.

Hammer D (1989). Two approaches to learning physics. Phy. Teach. 27(9): 664-670.

Hammer D (1995). Epistemological considerations in teaching introductory physics. Sci. Edu. 79(4): 393-413.

Hammer, D. (1994). Epistemological beliefs in introductory physics. Cognition and Instruction 12(2): 151-183.

Hogan K (1999). Relating students' personal frameworks for science learning to their cognition in collaborative contexts, Sci. Edu. 83(1): 1-32.

Jones RW (2006). Problem-based learning: Description, advantages, disadvantages, scenarios and facilitation. Anaesthesia and Intensive Care 34(4): 485-488.

Kortemeyer G (2007). Correlations between student discussion behaviour, attitudes, and learning. Physical Review Special Topics – Phy. Edu. Res. 3(1): 1-8.

Kwan CY (2000). What is problem-based learning (PBL): it is magic, myth and mindset. Problem Based Learning 3(3): 1-2.

Lederman NG (1992). Students' and teachers' conceptions of the nature of science: A review of the research. J. Res. Sci. Teach. 29(4): 331-359.

Levin BB (2001). Introduction. In: B. B. Levin (Ed.), Energizing teacher education and professional development with problem-based learning (p. 1-7). Alexandria, VA: Association for Supervision and Curriculum Development.

Levine TR, Hullett CR (2002). Eta squared, partial eta squared, and misreporting of effect size in communication research. Hum. Commun. Res. 28: 612-625.

Lin H (1982). Learning physics vs. passing courses. The Phy. Teach. 20(3): 151-157.

Lising L, Elby A (2005). The impact of epistemology on learning: A case study from introductory physics. Am. J. Phy. Phy. Edu. Section, 73(4): 372-382.

Major C, Palmer B (2001). Assessing the effectiveness of problem-based learning in higher education: Lessons from the literature. Academic Exchange Quarterly 5(1): 4-9.

Marx JJ, Cummings K (2007). What factors really influence shifts in students' attitudes and expectations in an introductory physics course? Proceedings of the 2006, American institute of physics. Phy. Edu. Res. Conf. 883: 101-104.

McDermott LC, Redish EF (1999). Resource letter PER-1: Physics education research. Am. J. Phy. 67: 755-767.

Mistades VM (2007). Exploring business students' and liberal arts students' beliefs about physics and physics learning. Asia Pac. Educ. Rev. 8(1): 100-106.

Moust JHC, Van Berkel HJM, Schmidt HG (2005). Signs of erosion: reflections on three decades of problem-based learning at Maastricht University. Higher Education 50: 665-583.

Norman GR, Schmidt HG (1992). The psychological basis of problem based learning: A review of the evidence. Acad. Med. 67: 557-565.

Norman GR, Schmidt HG (2000). Effectiveness of problem-based learning curricula: theory, practice and paper darts. Med. Edu. 34: 721-728.

Ornek F, Robinson WR, Haugan MP (2008). Students' expectations about an innovative introductory physics course. J. Turk. Sci. Edu. 5(1): 48-58.

Prince M (2004). Does active learning work? A review of the research. J. Eng. Edu. 93(3): 223-231.

Prosser M, Walker P, Millar R (1996). Differences in students' perceptions of learning physics. Phys. Educ. 31(1): 43-48.

Radloff A, de la Harpe B (2001). Learning strategy use in higher education: Changes over time for first year and mature age students. Paper presented at the European Association for Research into Learning and Instruction (EARLI) Conference, Fribourg, Switzerland, August.

Raine J, Collett J (2003). Problem-based learning in astrophysics. Eur. J. Phy. 24: 41-46.

Redish EF, Saul JM, Steinberg RN (1998). Student expectations in introductory physics, Am. J. Phy. 66(3): 212-224.

Rhem J (1998). Problem based learning: An introduction. Retrieved on 12 April 2009, from http://www.ntlf.com/html/pi/9812/pbl_1.htm.

Roth WM, Roychoudhury A (1994). Physics students' epistemologies and views about knowing and learning. J. Res. Sci. Teach. 31(1): 5-30.

Saarinen-Rahiika H, Binkley JM (1998). Problem-based learning in physical therapy: A review of the literature and overview of the McMaster University experience. Physical Therapy 78(2): 195-207.

Sahin M (2007). The importance of efficiency in active learning. J. Turkish Sci. Educ. 4(2): 61-74.

Sahin M (2009). Correlations of students' grades, expectations, epistemological beliefs and demographics in a problem-based introductory physics course. Int. J. Environ. Sci. Educ. 4(2): 169-184.

Sahin M (accepted for publication). Exploring university students' expectations and beliefs about physics and physics learning in a problem-based learning context. Eurasia J. Math. Sci. Tech. Educ.

Sander P, Stevenson K, King M, Coates D (2000). University students' expectations of teaching. Studies in Higher Education 25(3): 309-323.

Schoenfeld A (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In: Grouws DA (Ed.), Handbook of research in mathematics teaching and learning, New York: MacMillan pp. 334-370.

Songer NB, Linn MC (1991). How do students' views of science influence knowledge integration? J. Res. Sci. Teach. 28(9): 761-784.

Stonyer H, Marshall A (2002). Moving to problem-based learning in the NZ engineering workplace. J. Workplace Learn. 14(5): 190-197.

Tabachnick BG, Fidell LS (2001). Using multivariate statistics (4th ed.). Boston: Allyn & Bacon.

Torp L, Sage S (2002). Problems as possibilities: Problem-based learning for K-16 education (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Vernon DTA, Blake RL (1993). Does problem-based learning work? A meta-analysis of evaluative research. Acad. Med. 68: 550-563.