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Correlations of Students' Grades, Expectations, Epistemological Beliefs and Demographics in a Problem-Based Introductory Physics Course

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Аннотация

The purpose of this study was to determine the predictors of student grades in introductory physics courses utilizing problem-based learning (PBL) approach and traditional lecturing. The study employed correlational/predictive methods to investigate and describe/explain relationships of students' physics grades with their expectations, attitudes, epistemological beliefs about physics and physics learning, and demographic variables. The subjects involved in this study were 264 freshmen engineering students (PBL, n = 100; traditional, n = 164) at Dokuz Eylül University (DEU) in Izmir, Turkey. All students were surveyed at the beginning and at the end of the spring 2007 semester using the Maryland Physics Expectations Survey (MPEX) to determine their expectations, attitudes, and epistemological beliefs about physics and physics learning. Students' physics learning was measured via their end of semester physics grades. Correlational analyses indicated significant relationships between variables of the study. Forward stepwise linear regression analyses revealed the effort cluster and selected background variables (e.g., gender) as significant predictors of physics grades. Results suggest that further study is needed to investigate predictors and correlates of students' physics learning using qualitative measures to support and more clearly interpret the numerical findings.

Ключевые слова: expectations, problem-based learning, epistemological beliefs, physics

Introduction

Epistemological beliefs in the study of student learning are defined as views about how knowledge is constructed and evaluated. Recently, there has been a focus on students' epistemological beliefs in the literature (Adams et al., 2004; Hammer, 1994, 1995; Redish, Saul, & Steinberg, 1998; Schommer, 1994). Researches have shown that sophisticated student epistemological beliefs were correlated with success and conceptual understanding in science. Hence, it has been emphasized that students should be facilitated to improve their epistemological beliefs from a novice to a more expert-like level.

One important aim of physics education is to develop more expert-like views of physics and physics learning in students (Elby, 2001). With the hope to add to the previous research in examining the role of physics-related epistemological beliefs in physics learning, the present study has attempted to probe two questions: First, which student and course elements correlate with students' expectations, attitudes, and epistemological beliefs about physics and physics learning in different instructional contexts such as traditional lecture and PBL? Second, which student and course elements predict students' physics course grades in introductory physics classes, utilizing problem-based learning and traditional lecture approaches?

Student Expectations and Epistemological Beliefs about Physics Learning

Beliefs about what constitutes knowledge in physics and how knowledge is developed are described as epistemological beliefs about physics and physics learning (Kortemeyer, 2007). Different epistemological views can lead to very different understandings of the same scenario. For instance, physicists see the derivation of a formula as a way to improve their understanding, while students are found to see it as a proof that a formula is true and "okay to be used" (Redish et al., 1998).

Instructors most of the time in science courses 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." Research has shown that most students have beliefs about physics and physics learning very different from that of an expert physicist (Redish et al., 1998). These prior assumptions and expectations may affect students' learning of introductory physics.

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. Research has revealed that students can participate in instructional activities that help them learn conceptually without any impact on their beliefs about how to learn effectively (Elby, 2001). Several studies have investigated student learning experiences related to instructional environment and reported that an instructional focus on students’ epistemological beliefs might facilitate their physics learning in different ways (Elby, 2001; Linder & Marshall, 1997).

Students’ views, expectations, and beliefs about physics and science in general were evaluated using surveys, guided interviews, and observations (Kortemeyer, 2007). Surveys are the most frequently used instruments for this purpose. For instance, Redish and his colleagues (1998) developed the MPEX to determine students’ expectations about what they know and believe about physics and learning physics. The Views about Science Survey (VASS) developed by Halloun (1997), probes students’ views about the nature of science and about what it takes to learn science. Elby et al. (1999) developed the Epistemological Beliefs Assessment Survey (EBAPS) which measures how students function in a real science class rather than what they think about how they should function in an idealized situation. Extending the items on the MPEX, Adams et al. (2004) designed the Colorado Learning Attitudes about Science Survey (CLASS) to measure various facets of student attitudes and beliefs about learning physics.

Correlations of Students’ Epistemological Beliefs with Physics Learning

Recently, there has been a focus of research on the relationship of students’ epistemological beliefs and expectations with their physics learning (e.g., Hogan, 1999; Lederman, 1992; McDermott & Redish, 1999 and the references therein; Pomeroy, 1993). Previous research has found correlations between epistemological beliefs and academic performance (Hofer & Pintrich, 1997; Hofer, 2001). May and Etkina

(2002) reported correlations between epistemological beliefs extracted from extensive lab reports and conceptual learning gain in introductory physics courses. A case study has investigated the relationship among some pre-instructional knowledge, the learning gain, and the final physics performance of a sample of 47 Computing Engineering freshmen students in an introductory physics course at the University of Palermo, Italy (Capizzo, Nuzzo, & Zarcone, 2006). Results indicated that students' learning gain in physics was independent of students' initial level of mathematics skills and physics knowledge. Initial logic skills and reading comprehension abilities were not significant factors for the learning physics gain and the performance on physics courses. Stathopoulou and Vosniadou (2007) have investigated the relationship between secondary school students' physics- related epistemological beliefs and physics conceptual understanding. Regression analysis showed that beliefs regarding the Construction and Stability of physics knowledge and the Structure of physics knowledge were good predictors of physics understanding. Stathopoulou and Vosniadou suggested that sophisticated physics-related epistemological beliefs are necessary but not sufficient for physics understanding. Halloun and Hestenes (1985) have suggested that the more consistent the students' and instructors' views about learning physics were, the better these students performed in the course.

Kortemeyer (2007) has reported correlations between the MPEX and measures of student learning (final exam, ELI, and course grade). Correlations between the score on the coherence cluster and the course grade percentage, $r = 0.36$, was the highest reported. Perkins et al. (2005) have investigated the relationships between students' beliefs and their learning gains using the CLASS, the Force and Motion Conceptual Evaluation instrument (FMCE) (Thornton, & Sokoloff, 1998), and the Force Concept Inventory (FCI) (Hestenes, Wells, & Swack- hamer, 1992) data on 307 students. Significant correlations were reported between individual belief categories of the CLASS and normalized learning gain, calculated from FMCE scores. Correlations reported by Kortemeyer were in the same range with those reported by Perkins et al.

Different measuring instruments may produce different correlations with beliefs. For example, Coletta and Philips (2005) found a strong correlation between the MPEX and FCI gain, while Dancy (2002) found low correlations between the MPEX and the performance on homework, tests, and final exams. It should be kept in mind that there is no single cause influencing students' gains, attitudes, and interest in, and beliefs about physics (Marx & Cummings, 2007; Perkins et al., 2006; Pollock, 2005).

The literature on students’ epistemological beliefs in the field of introductory physics is limited (Elby, 2001; Hammer, 1989, 1994; Redish, et. al., 1998; Roth & Roychoudhury, 1994). Therefore, the present study aims to add to the epistemological research literature within this particular physics domain. Building upon the line of inquiry by Redish et al., the present study investigates the correlations of university students’ physics course grades, expectations, attitudes, and epistemological beliefs about physics and physics learning and the effect of PBL on these correlations. The study further investigates the relationships of various background variables with course grades and expectations.

It has been suggested that different instructional designs may have an impact on students’ epistemological beliefs and epistemology may have an impact on physics learning (Lising & Elby, 2005). Several studies have shown that traditional physics teaching was not successful in helping students develop a more scientific view of physics and physics knowledge (Redish et al., 1998). Part of the sample for the current study has been instructed via problem-based learning approach for several years.

Problem-Based Learning

Problem-based learning is an instructional approach where complex real world problems constitute the context for learning. Although there is agreement on the general definition of PBL, wide variations are observed in practice. In PBL sessions, groups of 6-8 students work through a given problem under the guidance of a tutor.

Several research-based teaching programs in physics suggest that instructional designs that employ active engagement, discussion, and group work are influential in student learning (e.g., Crouch & Mazur, 2001; Gautreau & Novemsky, 1997; Hake, 1998). Interactive engagement and problem-based instructional approach are widely accepted and used in physics education throughout the world (e.g., Barrows & Tamblyn, 1976, 1980; Edwards & Hammer, 2004; Fink, Enemark, & Moesby, 2002; Jones, 2006; McDermott & Redish, 1999; Saarinen- Rahiika & Binkley, 1998; van Heuvelen, 1991). The effects of these research-based approaches on students’ learning of physics have been documented in the literature (e.g., Akinoglu & Tandogan, 2007; Bernhard, 2000; Hake, 1998; Francis, Adams, & Noonan, 1998; McDermott, 1995, 1998). Sahin (2007) discusses the factors that may have important roles in the efficiency of PBL approach such as group work, integration of disciplines, and the role of tutor. In general, research indicates no significant difference between students’ science learning in the PBL and non-PBL classes (Albanese & Mitchell, 1993). However, a general finding in the literature is that PBL students develop more positive attitudes (Vernon & Blake, 1993). In the present study, data from traditional and PBL students were analyzed separately to see if there are differences between the correlations found for both groups.

Research Methodology

This study is a descriptive/correlational research seeking to identify correlational/predictive relationships of students’ learning in an introductory physics course, favorable scores on the MPEX, and selected demographic variables, such as gender, region, course feeling, and learning preferences. This type of research is useful in studies concerned with prediction and describing relationships (Ary, Jacobs, & Razavieh, 1996). Student 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).

The MPEX was administered both at the beginning and at the end of a spring semester to two groups of students in an engineering faculty where some of the departments had been utilizing problem-based active learning approach for couple of years. Instruction language was English in the departments where the study was conducted; therefore the MPEX was administered in its original form in English.

Problem-Based Learning at Dokuz Eyliil University

Some departments of engineering faculty of Dokuz Eyliil University replaced its traditional curriculum with a module-based PBL approach starting with the freshman class in fall 2002. Since then, departments of electrics and electronics (EE), geological, geophysics, and mining engineering have been using PBL curriculum while departments of computer, civil, environmental, mechanical, industrial, and metallurgical and materials engineering stayed on traditional curriculum. PBL has been first utilized at DEU in the school of medicine starting from 1997-1998 academic year.

PBL is constructed in the form of a modular approach. The purpose of modular structure is to enable students concentrate on the given problem and the learning outcomes. Freshman year modules are integrated scenarios within which a real-life problem is given including concepts from physics, mathematics, and sometimes from basic engineering, materials, and/or
chemistry. Modules last two to three weeks depending on the weight of the subject matter taught in the scenario. Each module consists of three or four PBL sessions lasting three to four classes each, lecture presentations on each discipline, physics and computer laboratories, and consultation and discussion hours.

The main portion of the process is the PBL sessions. PBL sessions aimed at discussion of real-life problems, constructed in the form of a scenario-like context, by groups of eight students. There is a TA or faculty member (tutor) guiding each group. The problem-solving process takes place in PBL sessions until the students reach and agree upon a solution to the given problem. The learning outcome for every session if applicable is determined by the program designers and scenario writers (mainly faculty members and tutors including physics and mathematics instructors). Students are guided via the scenario problems to reach the intended outcomes. 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 light of the new information provided in the next section of the scenario, and eliminate false hypotheses thus forming a hypothesis toward the solution of the problem. During the first PBL session, tutor provides feedback, asks guiding questions, and invites students to discuss their hypotheses. Students determine the concepts which they need to study and learn generally in the first session. Then they come to the next session prepared, studied and learned the necessary concepts required to solve the problem. The process takes three or four 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 four- five students carry out PBL physics labs. Traditional labs with lab manuals including everything about how to carry out the experiment (cookbook experiments) are not used in PBL labs. PBL program has also a project part. Students are grouped into five-six students and work together throughout the semester to plan, design, implement, and report projects, topics of which are usually decided upon by the instructors at the beginning of the semester. 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 and an end-of-semester exam that contains questions both in multiple choice and open-ended formats. Students’ end-of- module exam scores, PBL session scores, lab scores, and project scores are averaged and they are given a final score. Students who collect 70 or above are considered successful and students who collect below 70 are considered unsuccessful and need to repeat the module and hence the whole year.

Subjects

The study involved 264 freshmen engineering students at Dokuz Eyltil University in Izmir, Turkey. There were 100 students in the PBL group and 164 students in the traditional class. The number of females was approximately one-third of the males (76/188). Table 1 presents the sample of this study. PBL group students ranged in age from 19 to 23 years, with an overall mean age of 20.6 (SD = 1.32). Traditional group students ranged in age from 19 to 23 years, with an overall mean age of 20.4 (SD = 1.18). Traditional classes consisted of lecture and recitation sections, four classes per week in total. Students in traditional physics classes had no laboratory sections. The study was carried out in a second semester introductory physics course focused on electricity and magnetism concepts. Students involved in the study were from the department of electrics and electronics engineering and traditional group students were from the department of computer engineering. Therefore, the sample of this study was a
convenience sample. They were selected by virtue of being the students in the school where the researcher worked as an instructor (Sander et al., 2000).

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

Gender	PBL Group		Traditional Group		Total
	n	%	n	%	

Female	30	30	46	28	76
Male	70	70	118	72	188
Total	100	100	164	100	264

Survey Tool: The Maryland Physics Expectations Survey

The MPEX is a widely used survey primarily intended to evaluate the impact of one or more semesters of instruction on an overall class. The MPEX consists of 34 items which were rated on a five point Likert-scale from strongly disagree (1) to strongly agree (5). The MPEX focuses on six facets according to which students’ beliefs about the nature of physics learning are classified: Beliefs about physics learning (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 (E ffort). The italics indicate the MPEX clusters. The authors 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. Student scores were calculated in comparison to the ‘favorable’ expert responses given by the authors of the instrument. Beginning and end of the semester scores were calculated for participating students. The same calculation was done for each cluster of the MPEX. Sample statements from the MPEX are given, including expert answers in parentheses:

Independence (Unfavorable): In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as given.

Coherence (Unfavorable): Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.

Concepts (Favorable): When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.

Reality link (Unfavorable): Physical laws have little relation to what I experience in the real world.

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.

Effort (Favorable): I go over my class notes carefully to prepare for tests in this course.

Research Questions

Following research questions were probed in the study:

1. Which student and course elements correlate with students' expectations, attitudes, and epistemological beliefs about physics and physics learning in different instructional contexts such as traditional lecture and PBL?
2. Which student and course elements predict students' physics course grades in introductory physics classes, utilizing problem-based learning and traditional lecture approaches?

Data Collection and Analyses

Data were collected via the application of the MPEX survey to 264 freshmen engineering students at Dokuz Eyliil University during the 2006-2007 spring semester, in introductory physics classes. The MPEX was administered at the beginning of first classes and again before the final exams at the end of the second semester. Pre-administration data were collected from 327 students; however, in order to eliminate the confounding factor of differential dropout rates, only students (n = 264) who completed the MPEX both at the beginning and at the end of the semester were included in the analyses. Hence, the data can be said to be matched. Demographic variables were collected via the application of a demographic information sheet during the first application of the MPEX. Traditional group physics grades were calculated from homework, two midterms, and a final exam. Although student final grades may not be as representative as research-based physics learning assessment tests, such as the Force Concept Inventory (ECI), based on the final scores, students get their final letter grades and this is regarded as their physics understanding and learning. In this study, only student final grades were available as a measure of their physics understanding and used as the dependent variable. There is not any pre-measure of students’ physics knowledge. 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 hence they were tested using the same tests in all exams.

Data were analyzed using SPSS 13.0 statistical analysis program. Means, standard deviations, and standard errors were determined and correlational and regression analyses were carried out to find the relationships between variables. Following Redish et al. (1998), the results are presented by specifying the percentage favorable responses to items in six clusters. 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. Variable region represents the region of Turkey where students’ high schools are located. Variable prep school represents whether students attended one-year English prep school before starting their university education and was coded as 1 = yes, 0 = no. Variable course feeling represents students’ prior feelings or expectations about the course and was coded as 1 = negative, 2 = neutral, and 3 = positive. Variable learning preference represents students’ preferred strategy of leaming/studying physics and was coded as 1 = listening, 2 = reading, 3 = writing, 4 = doing.

Results

Means and standard deviations for all the measures are presented in Table 2. Summary of correlations between the MPEX clusters and physics grades, including non-significant correlations and predictors of physics grades for both groups are shown in Table 3.

Results for PBL Group

As can be seen in Table 3, only effort cluster (beliefs about the kind of activities and work necessary to make sense out of physics) among the MPEX clusters was significantly correlated with PBL students’ physics grades ($r = 0.25$; $p < 0.05$). In addition, PBL group physics grades significantly correlated with learning preference ($r = -0.23$; $p < 0.05$).

Table 2. Descriptive statistics for PBL and traditional groups

Variable	PBL Group			Traditional Group		
	M	SD	n	M	SD	n
Physics grade	64.97	1.71	100	71.41	11.78	164
Overall MPEX	38.13	14.88	100	38.14	13.77	164
Independence	28.70	20.76	100	31.43	20.38	164
Coherence	24.60	20.67	100	30.98	21.28	164
Concepts	36.60	20.90	100	38.29	23.38	164
Realty link	50.75	30.87	100	44.82	29.63	164
Math link	35.40	23.76	100	38.29	24.31	164
Effort	47.20	23.01	100	46.95	26.45	164
Gender	1.70	0.46	100	1.72	0.45	164
Region	2.51	1.51	100	3.00	1.71	164
Prep school	0.86	0.35	100	0.71	0.46	164
Course feeling	2.50	0.54	100	2.39	0.68	164
Learning preference	2.93	1.01	100	2.84	1.01	164

Correlations of overall MPEX score, independence, coherence, concepts, reality link, and math link clusters with physics learning were very low, ranging between r = 0.00 for concepts cluster and r = -0.08 for coherence cluster, and not significant for PBL students.

All the clusters correlated with the overall MPEX score significantly and positively, with correlations ranging from 0.41 to 0.71. Region was found to be positively correlated with overall MPEX score ($r = 0.21$; $p < 0.05$) and concepts cluster ($r = 0.20$; $p < 0.05$). There were significant correlations between learning preference and overall MPEX score ($r = -0.20$; $p < 0.05$), effort cluster score ($r = -0.27$; $p < 0.01$), and prep school ($r = -0.23$; $p < 0.05$). PBL students who preferred to learn physics via listening and reading tended to have higher scores on overall MPEX and effort clusters and also tended to attend English prep school before starting departmental education.

In order to test for the effects of the MPEX dimensions and other student variables on physics learning (measured by physics grade), a stepwise regression analysis with the physics grade as the dependent variable was carried out. Results are displayed in Table 4. Effort was identified as the only significant predictor of PBL students’ physics grades. This variable accounted for 6% of the variance explained for the dependent variable physics grade. A positive beta value (ß = 0.25; $p < 0.05$) was obtained, indicating that PBL students who had higher favorable means on the effort cluster had higher physics grades than those who had lower percentage of agreement to favorable (expert) views on the effort cluster. The corresponding regression model was significant ($F_{[i, 98]} = 6.52$; $p < 0.05$) and yielded an adjusted 7?^{2} of 0.05.

Table 3. Summary of significant correlates and predictors of physics grades

Dependent	PBL Group (n	= 100)	Traditional Group (n = 164)	
Variable	Correlations (r)	Predictors	Correlations (r)	Predictors

Physics Grade	Effort* Learning preference* Overall (0.03) Independence (-0.05) Coherence (-0.08) Concepts (0.00) Reality link (-0.03) Math link (-0.01)	Effort (+)	Effort* Gender** Region* Prep school** Overall (0.08) Independence (-0.15) Coherence (0.00) Concepts (-0.01) Reality link (0.08) Math link (0.13)	Prep school (-) Gender (-) Region (-) Effort (+) Learning preference (-)

Note-. Significant for *p < 0.05; **p < 0.01. Parentheses in correlations indicate Pearson correlation coefficients

Table 4. Regression of variables to determine the predictors of physics grades for PBL group (n = 100) (Forward stepwise entry)

Variable	R	R^2	Adjusted R^2	B	ß	t	P
Effort	0.25	0.06	0.05	0.13	0.25	2.55	0.012

Results for Traditional Group

As can be seen in Table 3, among the MPEX clusters, only effort cluster was significantly correlated with traditional group physics grades ($r = 0.17$; $p < 0.05$). In addition, traditional group physics grades significantly correlated with gender ($r = -0.20$; $p < 0.01$), region ($r = - 0.19$; $p < 0.05$), and prep school ($r = -0.21$; $p < 0.01$).

Correlations with the MPEX scores and physics grades for traditional group were also very low ranging from $r = 0.00$ for coherence cluster to $r = -0.15$ for independence cluster and not significant. Two notable correlations were found between traditional group students’ scores on the independence ($r = -0.15$; $p = 0.06$) and math link ($r = 0.13$; $p = 0.09$) clusters. These correlations were significant at $p = 0.1$ level but not at $p = 0.05$ level.

Correlations among the clusters of the MPEX yielded some insignificant results. Correlations between the independence, and reality link and effort clusters were very low and not significant. In addition, correlations between the coherence, and concepts and effort clusters were also low and not significant.

All the clusters correlated with the overall MPEX score significantly and positively, with correlations ranging from 0.39 to 0.69. Gender was significantly related to the independence cluster ($r = 0.17$; $p < 0.05$) with males more likely to have higher percent of agreement to favorable responses than do females. Region was found to be positively correlated with the in
dependence cluster ($r = 0.23$; $p < 0.01$). There were significant correlations between course feeling and the coherence cluster ($r = -0.15$; $p < 0.05$) and gender ($r = 0.16$; $p < 0.05$). Males were more likely to report positive course feeling at the beginning of the semester than females among traditional students. Learning preference was found to be positively correlated with math link cluster ($r = 0.19$; $p < 0.05$).

In order to test for the effects of the MPEX dimensions and other student variables on physics learning, a stepwise regression analysis with the physics grade as the dependent variable was carried out for traditional group. Results are displayed in Table 5. Variables prep school, gender, region, effort, and learning preference were identified as significant predictors of traditional group physics grade. The combination of these variables accounted for 18% of the variance explained for the dependent variable. One positive beta value for effort (ß = 0.17; $p < 0.05$), and four negative beta values, for prep school (ß = -0.19; $p < 0.01$), gender (ß = - 0.23; $p < 0.01$), region (ß - -0.18; $p < 0.05$), and learning preference (ß = -0.15; $p < 0.05$) were obtained, indicating that females in traditional group who preferred to learn physics via reading and listening, not attended prep school, had higher favorable mean scores on the effort cluster, and come from southern-eastern parts of Turkey tended to have higher physics grades than males who preferred to study physics via writing and doing, attended prep school, had lower effort scores, and come from northern-western parts of Turkey. The corresponding regression model was significant ($F_{[6,}$ $i_{57]} = 5.54$; $p < 0.01$) and yielded an adjusted $7?^2$ of 0.14.

Table 5. Regression of variables to determine the predictors of physics grades for traditional group (n = 164) (Forward stepwise entry)

Variable	R	R^2	Adjusted R^2	B	ß	t	P
Prepschool	0.21	0.04	0.04	-5.20	-0.19	-2.77	0.006
Gender	0.29	0.08	0.07	-5.90	-0.23	-2.89	0.004
Region	0.33	0.11	0.09	-1.22	-0.18	-2.40	0.018
Effort	0.39	0.15	0.13	0.08	0.17	2.31	0.022
Learning preference	0.42	0.18	0.14	-1.74	-0.15	-1.99	0.048

Discussion

Summary and Discussion of Findings from Simple Correlational and Regression Analyses

This study used a correlational/predictive approach to investigate and describe/explain the relationships between the variables. The purpose of this study was to determine the correlations of university physics students' expectations, attitudes, epistemological beliefs about physics and physics learning, and selected demographic variables with their physics course grades. It can be argued that this study was successful in achieving its goals.

Following findings are explored to provide answers to the research questions probed in the study. For dependent variable: physics grade, simple correlational and linear regression analyses indicated that

1. This variable significantly correlated with effort (+) and learning preference (-) for PBL group. However, effort (+) was identified as the lone significant predictor of PBL group physics grades, indicating that PBL students who showed higher agree ment to favorable views on the effort cluster tended to get higher physics grades than those who had lower scores on the effort cluster.
2. Traditional group physics grade significantly correlated with effort (+), gender (-), region (-), and prep school (-). Variables prep school (-), gender (-), region (-), effort (+), and learning preference (-) were identified as the best combination of significant predictors for this variable, indicating that in traditional group, females who preferred to learn physics via reading and listening, not attended prep school, had higher favorable mean scores on the effort cluster, and come from southern-eastern parts of Turkey tended to have higher physics grades than those who were males, preferred to study physics via writing and doing, attended prep school, had lower effort scores, and come from northern-western parts of Turkey.

Results of correlational and regression analyses showed that PBL students who made the effort to use information available and tried to make sense of it tended to have higher physics grades than those who did not attempt to use available information effectively. Perkins et al. (2005) have also reported a positive correlation for the student beliefs on the sense mak- ing/effort dimension of the CLASS and their FMCE learning gains.

Correlation of the traditional students’ physics grades with effort cluster was also similar to one reported in Perkins et al. (2005). Dancy (2002) has also reported correlations between the MPEX clusters and the performance on homework, tests, and final exams. However, Dancy’s finding that no significant correlation was found for the effort cluster, contrasted the results reported in the present study and others in the literature (Perkins et al., 2005). Although gender was identified as a significant variable in this study, females constitute only one-third of the sample. Therefore, caution is advised when interpreting the results for gender difference.

The results of the present study suggest that whether it is a traditional introductory physics class or one that employs PBL method, students’ beliefs about the kind of activities and work necessary to make sense out of physics (the effort cluster of the MPEX) play a critical role in their physics learning. There are also weak correlational findings that may suggest that beliefs about learning physics—whether it means receiving information or involves an active process of reconstructing one’s own understanding (the in dependence cluster of the MPEX) and beliefs about the role of mathematics in learning physics—whether the mathematical formalism is just used to calculate numbers or is used as a way of representing information about physical phenomena (the math link cluster of the MPEX) may be related to physics grades of students in the present study. Traditional students who considered mathematics as a convenient way of representing physical phenomena tended to have higher physics grades, however, interestingly, traditional students who believed that understanding physics was taking what was given by authorities (teacher, text) without evaluation, also tended to have higher physics grades (these correlations were not significant though).

Conclusion

A significant variable (effort) was identified for predicting PBL students’ physics grades. Although the variance in students’ grades explained by this predictor is not very large (6%), this variable may indicate an effect of PBL program on students’ beliefs about physics learning. It may present that PBL students who show effort and study hard tend to obtain higher physics grades. The same analysis for traditional group has resulted in a larger percent (18%) of variance explained by the predictor variables. In addition, contrary to a single correlating variable in PBL group, there were several variables correlated with traditional students’ physics grades. Although significant, correlations of variables with physics grade were not high for both groups. The highest correlation found was 0.25 for PBL students.

Low level of correlations may be regarded as a drawback for the study’s findings, however, significant correlations especially for traditional group revealed meaningful results. For instance, coming from a rote learning instructional approach students’ physics learning (grades) were found to correlate with whether they have attended one-year prep school. Those who attended prep school earned lower grades which may well be as a result of not being able to remember high school physics concepts after one year. A significant limitation of this study was not being able to measure students’ physics learning by standardized instruments, such as FCI or FMCE. As significant correlations found in the present study and in the literature suggest, course grades can also serve as a measure of physics learning to some extent, however, it might have been called problem solving ability instead of physics learning.

PBL is an interactive engagement approach employed at DEU for the purpose of improving students’ learning and creative thinking skills and preparing them to be better equipped engineers for their future careers. Based on the results of the present study it is doubtful that this approach works for freshmen students in electrical and electronics engineering department since PBL approach does not seem to make a difference in their physics learning. Traditional students obtained higher average physics grades than PBL students on similar exams. In addition, both groups obtained similar average favorable scores on the overall MPEX which means that PBL approach did not make any impact on students’ beliefs about physics and physics learning. It can be argued that PBL had no effect in improving freshmen engineering students’ epistemological beliefs from a novice to a more expert-like level. Although not reported in this paper, favorable MPEX scores for both groups have dropped similarly and substantially from pre-application to post which indicates that PBL had no influence on students’ epistemological beliefs about physics and physics learning.

A plausible explanation for non-significant differences is that there may be some drawbacks of PBL approach caused by flawed application process at DEU. Researcher’s personal communication with PBL students and their written responses to open-ended assessment questions about PBL approach indicate that although some students find PBL useful and effective for improving and developing their communication, critical and creative thinking, and problem solving skills, others find PBL not effective for their physics learning. There were several reasons students mentioned for indicating PBL as an ineffective instructional approach such as insufficient time to prepare for module exams, not being able to manage self-directed learning, and insufficient presentations (lecturing) and traditional problem solving hours for physics. These are simply complains about PBL approach which puts students in charge of their own learning. Students very often indicate their wish to go back to traditional instruction in which they just sit and listen to instructor. PBL is a radical change as compared to traditional lecturing which is the most widely used instructional approach in high schools in Turkey. Students can not adapt to PBL approach in a short time. There are also other factors that students brought up in their responses, such as negative tutor and guidance behaviors in PBL sessions, quality of the scenarios (problems), and their lack of interest in basic science courses. Although not significant, an interesting finding was that traditional students who believed in lecturing as the way of physics learning tended to have higher physics grades. This finding may indicate that students have showed effort just to pass the course not for meaningful understanding. It may also show the ineffectiveness of PBL approach on students’ physics grades.

Implications for Physics Education and Research

The results of the present study add to those of previous research on the role of physics-related epistemological beliefs in physics learning. Researchers have emphasized the importance of constructivist instruction in facilitating the development of sophisticated epistemological beliefs in science (e.g., Elby & Hammer, 2001; Roth & Roychoudhury, 1994). Since it has been argued that sophisticated epistemological beliefs that students have would add to their understanding of physics (Stathopoulou & Vosniadou, 2007) this line of research should continue in physics education to shed more light on student beliefs to promote awareness and improve sophisticated beliefs about physics and physics learning.

Significant findings were obtained in the present study which suggest that carefully developed further research should be conducted including extended background variables such as prior ideas and beliefs about physics in general and the particular physics course they will take, curricula employed in different departments, instructor differences, and gender. Since PBL approach was adapted to improve the quality of teaching and learning at DEU engineering faculty, the impact it produces (if any) on student attitudes, beliefs, and learning should be investigated and if necessary revisions should be undertaken on the program.

An important limitation in the present study was not being able to control the variables. Further studies in this field could use more controlled variables and mixed methods of research. Using qualitative measures (i.e., observations and interviews) to support and more clearly interpret the numerical findings of the study and also using standardized measures for student learning would add to reliability and internal validity of the research.

In terms of PBL approach, results of the present study indicate that there are problematic areas in the application process at DEU and these problems may be hindering the potential benefits students can get out of PBL. Administrators and educators who want to provide a better engineering education for their students may want listen to what their students think about PBL.

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