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Exploring University Students' Expectations and Beliefs about Physics and Physics Learning in a Problem-Based Learning Context

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This paper reports the results of an exploratory study aimed to determine university students' expectations and beliefs in a problem-based introductory physics course, how those expectations compare to that of students in other universities, and change as a result of one semester of instruction. In total, 264 freshmen engineering students of Dokuz Eylul University (DEU) in Izmir, Turkey enrolled in the study. The study involved two groups, first group (n = 100) was instructed via modular-based active learning (problem-based learning [PBL]) method and second group (n = 164) by traditional lecture method. Data were collected through pre and post application of the Maryland Physics Expectations (MPEX) survey. Students' average favorable and unfavorable percentage scores were determined. The results showed that average favorable scores of both groups were substantially lower than that of experts and that of other university students reported in the literature. Students' favorable scores have dropped significantly after one semester of instruction. PBL and traditional groups displayed similar degree of 'expert' beliefs. The results of this study showed that university students' expectations and beliefs about physics and physics learning have deteriorated as a result of one semester of instruction whether in PBL or traditional context. Implications of the results were discussed.

Keywords: Beliefs, Expectations, Introductory Physics, MPEX, Problem-Based Learning.

INTRODUCTION

It has been suggested that students' expectations and beliefs about physics influence their study strategies and were related to their conceptual development (Chu, Treagust, & Chandrasegaran, 2008). Expectations are beliefs about the learning process and the structure of knowledge (Mistades, 2007). These beliefs have 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 approach 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.

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Problem-based learning

Problem-based learning (PBL) is an interactive instructional approach and has attracted much interest since its administration at McMaster University over four decades ago (Barrows and Tamblyn, 1976, 1980). It has gained prominence as a way of instruction in a wide variety of disciplines including medicine, engineering, and education among others (Edens, 2000; Edwards and Hammer, 2004; Eldredge, 2004; Fink, Enemark, and Moesby, 2002; Jones, 2006; Kwan, 2000; Saarinen-Rahiika and Binkley, 1998; Sahin, 2009, in press; Selcuk and Sahin, 2008; Stonyer and Marshall, 2002). PBL was not a popular mode of instruction in physics until last decade or so (Duch, 1995, 1996; Raine and Collett, 2003; Sahin, 2007; Sahin and Yörek, 2009).

The history of PBL and its definitions are covered in detail by Gijbels et al. (2005) and by Prince (2004) amongst others and do not need to be addressed here. However, it is worth mentioning here that the key characteristic of PBL, 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. 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). In this approach, learning is more student-centered, and less teacher-directed. Self-directed and team learning are two key features of PBL (Creedy and Hand, 1995).

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. Considerable research has been conducted on the effectiveness of PBL, evidenced in several considerable reviews of literature (Albanese and Mitchell, 1993; Berkson, 1993; Colliver, 2000; Norman and Schmidt, 1992, 2000; Major and Palmer, 2001; Prince, 2004; Vernon and Blake, 1993). There is a major educational issue about the effectiveness of PBL. 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 content (as measured by Part I of the National Board of Medical Examiners exam), 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 that '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, Alcazar 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. This sample of existing literature suggests that further studies are needed in order to better understand the effectiveness of PBL in specific contexts.

The decreasing enrollment in physics has led many physics educators to search for alternative ways of instruction, and the success of PBL in medicine and engineering, particularly in motivating students, makes PBL a strong candidate. In line with constructivist views, the learning process in PBL is based on prior knowledge and takes place in the context of the "real world" (Savery and Duffy, 1995). University physics courses are usually based on content and teacher-centered, and the curriculum is such that the students are taught all of the basic physics, mathematics, and laboratory skills in the first years. Students are not exposed to applications of the basic theory and exploratory projects until the final years of the program. Moreover, the traditional methods of teaching physics are not appropriate for mixed-ability teaching or developing skills in group work. A key element of PBL is its potential for mixed-ability classes. Complex problems require students to work together and rely on each other to solve them; thereby students take on an active role in constructing knowledge and engaging in inquiry and problem-solving skills (Allen, 2005).

The literature on the effectiveness of PBL in physics education is comparatively scarce (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 (Akınoğlu and Tandoğan, 2007). 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 (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. PBL and traditional groups were found to be no different in their responses to the

MPEX and in their physics grades. In addition, students who showed effort and studied hard tended to obtain higher physics grades. Sahin (in press) reported that PBL approach has no positive influence on engineering students' achievement and expectations about physics and physics learning.

This sample of existing literature suggests conflicting views on the efficacy of PBL as an approach; 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. In addition, the literature is scarce on the effect of PBL approach on students' expectations and beliefs about physics and physics learning. Consequently, with the hope to contribute to physics education and PBL literature, this study aims to determine the expectations of students enrolled in a calculus-based introductory physics course utilizing problem-based learning approach and compare these to that of students from other universities.

Expectations about physics

The phrase expectation was used (Redish, Saul, and Steinberg, 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. 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. These pre-conceptions may inhibit students' learning of the required material in their physics course (Mistades, 2007). Researchers who investigated students' beliefs and expectations and their role in physics learning have reported that students' expectations and beliefs 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. Other studies at the pre-college level determined some critical factors that comprise the relevant elements of a student's system of expectations and beliefs. 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. Research on students' beliefs is important since they affect motivation (Hofer and Pintrich, 1997) and influence students' selection of learning strategies (Edmonson, 1989; Schommer, Crouse, and Rhodes, 1992). Beliefs are also found to be related to the ability to reason on applied tasks (Qian and Alvermann, 1995), how students solve physics problems (Hammer, 1994), conceptual learning gain in introductory physics courses (May and Etkina, 2002), and conceptual understanding (Songer and Linn, 1991) in middle school and university levels.

Students' views, expectations, and beliefs about physics and science in general were measured using surveys, guided interviews, and observations (Kortemeyer, 2007). Surveys were the most frequently used instruments for this purpose. For example, 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) are some of them to mention. Since research has found relationships between students' beliefs and their performance on the course, studies have focused on this area during the last decade. Except for several studies which have 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, Robinson, and Haugan, 2008).

Aforementioned studies emphasize the importance of expectations 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 (Elby, 2001; Hammer, 1989, 1994, 1995; Roth and Roychoudhury, 1994; Redish et al., 1998). Therefore, the present study aims to add to the research literature within this particular physics domain. Building upon the line of inquiry by Redish et al. (1991) this study explores student expectations and beliefs about introductory physics and how those expectations and beliefs change as a result of one semester of instruction in problem-based learning and traditional lecture methods. In addition, students' expectations and beliefs were compared to that of students from other universities employing different research-based instructional methods.

The Maryland physics expectations (MPEX) survey

The MPEX developed by Redish et al. (1998) is a widely used survey primarily intended to evaluate the impact of one or more semesters of instruction on an overall class. The MPEX instrument 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' 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. It was assumed that experts, when asked what answers they would want their students to give, would respond consistently. 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 facets (clusters) 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.

To display the results in a concise and easily interpretable manner, Redish et al. (1991) introduced an agree-disagree (A-D) plot. In this plot, the percentage of respondents in each group answering favorably is plotted against the percentage of respondents in each group answering unfavorably.

METHODOLOGY

This is an exploratory study that investigates students' expectations and beliefs about physics and physics learning. The study explores student expectations in a problem-based learning context and compares these to that of students from other universities.

Sample

The study was carried out in a second semester calculus-based introductory physics course focused on electricity and magnetism concepts. Students involved in the study were all engineering students enrolled in six different departments. Therefore, 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. The study involved 264 freshmen students. There were 100 students in the PBL group and

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

	PBL Group		Traditional Group		Total	
Gender	n	%	n	%	n	%
Female	30	30	46	28	76	29
Male	70	70	118	72	188	71
Total	100	100	164	100	264	100

these were students in the departments of electrical and electronics, geological, and geophysics engineering and 164 students in the traditional classes and these were students in the departments of civil, environmental, and computer engineering). The number of females was approximately one-third of the males (76/188). PBL 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).

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 vagueness and 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 original 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. Examples of favorable and unfavorable answers for each cluster are given in Table 2.

The MPEX score represents percent agreement with the majority of an expert group. In order to eliminate the confounding factor of differential dropout rates, only students who completed the survey both at the beginning and at the end of semester were included. Hence, we can say that the data was matched. Beginning and end of the semester scores were calculated for participating students. As described by Redish et al. (1998), the following clusters of learning physics are probed in the MPEX:

(1) Independence. Students take responsibility for constructing their own understanding, rather than taking what is given by authorities (teacher, text) without evaluation.

(2) Coherence. Students believe that physics needs to be considered as a connected and coherent framework, rather than a set of unrelated facts or "pieces."

(3) Concepts. Students stress understanding of the underlying ideas and concepts, rather than memorizing and using formulas.

(4) Reality link. Students believe that ideas learned in physics are relevant and useful in a wide variety of real contexts, rather than having little or no relation to outside experiences.

(5) Math link. Students consider mathematics as a convenient way of representing physical phenomena, rather than viewing physics and mathematics as having little or no relationship.

(6) Effort. Students make the effort to use information available and try to make sense of it, rather than not attempting to use available information effectively.

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 in Engineering Faculty of DEU have replaced its traditional curriculum program with a modular PBL approach starting with the freshman class in Fall 2002. PBL curriculum at DEU is supposed to motivate and 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 within 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

Table 2. Examples of favorable and unfavorable items of the MPEX.

Cluster	Favorable(F)/Unfavorable(U) item
Independence	U: In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens.
Coherence	U: Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.
Concepts	F: When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.
Reality link	U: Physical laws have little relation to what I experience in the real world.
Math link	U: 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	F: I go over my class notes carefully to prepare for tests in this course.

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 no lab manual in the PBL labs, students are provided with a brief description sheet about the experiments.

In addition, PBL program has a project part. Students are grouped into 5-6 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. During the process, students are monitored, evaluated, guided, and encouraged 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, lab scores, 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 application of the MPEX to 264 freshmen engineering students of Dokuz Eylul University during the second semester of 2006-2007 academic year. The MPEX was administered at the beginning of first class of the second semester and again before the final exams at the end of the semester. Pre-administration data were collected from 327 students; however, to obtain matched pre-post data, only those students who took the MPEX as both a pre- and a post-assessment (n = 264) were included.

Following Redish et al. (1998), the results are presented by specifying the percentage of favorable versus unfavorable 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. For the analysis in this paper, following Redish et al. (1998), agree and strongly agree responses (4 and 5) were added together and disagree and strongly disagree responses (1 and 2) were added together.

Data from the University of Maryland (UMCP), the Ohio State University (OSU), the University of Minnesota (UMN), and Dickinson College as reported in Redish et al. (1998) and the Purdue University as reported in Ornek et al. (2008) were added to the analyses for comparison purposes. At Maryland, Ohio State, and Minnesota, classes were presented in traditional lecture-lab-recitation framework. At Dickinson College, the classes were presented in the

Table 3. Characteristics of the instructional contexts of the present study.

Institution	Instructional Characteristics	N
Dokuz Eylül University, Izmir,Turkey (DEU) PBL group	*(Modular) Problem-based active learning, with group learning PBL tutorials, traditional presentations, labs, and small projects*	100
Dokuz Eylül University, Izmir,Turkey (DEU) Traditional group	*Traditional lectures and recitations with no labs*	164
University of Maryland, College Park (UMCP)	Traditional lectures, some classes with group-learning tutorial instead of recitation, no lab	445
University of Minnesota, Minneapolis (UMN)	Traditional lectures, with group-learning research designed problem-solving and labs	467
Ohio State University, Columbus (OSU)	Traditional lectures, group-learning research designed problem-solving and labs	445
Dickinson College (DC)	Workshop Physics Laws (1991), no formal lectures. Instead, activities and observations. Observations are enhanced with computer tools for the collection graphical display, analysis and modeling of real data	115
Purdue University	Modeling-based interactive teaching consists of three parts, interactive lectures, small group work, computer labs, and no regular labs	38

Workshop Physics environment which replaces lectures with a combined lab and class discussion (Laws, 1991). At Purdue, physics classes were presented via modeling-based interactive teaching. The structure of the courses and the number of students in the current study are summarized in Table 3, including other universities. In Table 3, all data are matched; i.e., all students included in the reported data completed both the pre- and post-instruction surveys.

Table 4 displays DEU engineering students' MPEX percentage scores in the form of favorable/unfavorable in each cluster and overall. For instance, in Table 4, "DEU PBL pre, independence" cell indicates that, in pre-application, 35% of students' responses to items in the independence cluster were favorable, while 39% were unfavorable. The percentage of neutrals and not answering can be obtained by subtracting the sum of the favorable and unfavorable responses from 100. The table also includes student responses from other universities for comparison purposes. Figures 1-3 represent the same data in agree-disagree plots.

RESULTS AND DISCUSSION

Student responses were analyzed through the 6 dimensions of the MPEX, which revealed the structure of their beliefs on learning physics (Table 4). The initial state of PBL and traditional students at DEU differs substantially from the expert results as indicated in Table 4. 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 traditional students agreed with the favorable (expert) 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. What is interesting and perhaps discouraging is that all DEU students displayed considerably high percentages of unfavorable beliefs. PBL group showed unfavorable beliefs 17% - 39% of the time in the first deployment, 20% - 44% of the time in the post deployment and traditional students agreed with the unfavorable responses about 21% - 41% of the time in the first deployment, and 28% - 41% of the time in the post deployment. PBL students' unfavorable views have increased from pre application to post except for the concepts cluster for which the unfavorable views of students have decreased. Traditional group students displayed same percentage of unfavorable views in the first and post deployment of the MPEX in the independence, concepts, and math link clusters, and increasing unfavorable views from pre to post application of the MPEX in the other clusters. Overall, in the first deployment, PBL and traditional students agreed with the favorable (expert's) responses only about 47% and 44% and with the unfavorable responses about 30% and 32% respectively. Their favorable expectations in the post deployment of the MPEX were the same, 38%, and unfavorable expectations were 33% and 35% respectively.

PBL students showed 65% (highest) agreement with the favorable responses in the reality link cluster and

Table 4. Percentages of favorable/unfavorable responses on overall and clusters of the MPEX survey at the beginning and end of the semester.

Groups	Overall	Ind.	Coh.	Con.	Reality link	Math link	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*
DEU PBL 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*
DEU trad. post	*38/35*	*31/41*	*31/40*	*38/36*	*45/28*	*38/32*	*47/28*	
UMCP pre	54/23	54/25	53/24	42/35	61/14	67/17	67/13	445
UMCP post	49/25	48/27	49/27	44/32	58/18	59/20	48/27	
UMN pre	59/18	59/19	57/20	45/27	72/9	72/11	72/11	467
UMN post	57/20	58/20	61/17	46/28	69/10	72/12	63/16	
OSU pre	53/23	51/24	52/21	37/36	65/10	65/13	66/16	445
OSU post	45/28	46/28	46/26	35/35	54/17	55/20	44/30	
DC pre	61/15	62/14	58/17	47/23	76/4	70/10	75/7	115
DC post	60/19	67/14	66/18	58/23	72/9	71/12	57/26	
Purdue Pre	72/18	57/22	60/21	65/16	68/14	63/16	54/20	38
Purdue Post	59/17	54/18	58/21	67/13	67/9	56/17	49/26	

Note: Ind.:independence; Coh.: coherence; Con.: concepts.

35% (lowest) agreement with the favorable responses in the independence cluster in the first deployment of the MPEX. In the post deployment of the MPEX, they showed 51% (highest) agreement with the favorable responses in the reality link cluster but 25% (lowest) agreement with the favorable responses in the coherence cluster. Traditional students showed 53% (highest) agreement with the favorable responses in the reality link cluster and 34% (lowest) agreement with the favorable responses in the independence cluster in the first deployment of the MPEX. Traditional group showed the highest and the lowest agreements in the same clusters as the PBL students. In the post deployment of the MPEX, traditional students showed 47% (highest) agreement with the favorable responses in the effort cluster and 31% (lowest) agreement with the favorable responses in the independence and coherence clusters. All DEU students' expectations deteriorated as a result of one semester of instruction, whether in PBL or traditional classes.

Among the six clusters, all students showed relatively unfavorable expectations in the independence, coherence, and concepts dimensions that reveal beliefs about learning physics and the structure of physics knowledge. This reveals that the students involved in this study tended to regard learning physics as a kind of memorization of separate pieces of information and take what is given by instructors without evaluation. Students showed relatively favorable expectations in the reality link, math link, and effort clusters that reveal beliefs about the connection between physics and reality, the role of mathematics in learning physics, and the kind of activities and work necessary to make sense out of physics. This reveals that the students involved in this study tended to believe that ideas learned in physics are relevant to their outside experiences, consider mathematics as a convenient way of representing physics phenomena, and make effort to use available information and try to make sense out of it. These results are, however, considerably weak since students' favorable views as compared to those of expert beliefs are substantially low.

Redish et al. (1998) 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 such as the University of Washington tutorials (McDermott, 1998), the University of Minnesota context rich problems (Heller, Keith and Anderson, 1992), and Dickinson College Workshop Physics (Laws, 1989). These active-engagement approaches are shown to result significantly better conceptual learning than traditional curricula do, as measured by the Force Concept Inventory (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).

Overall, all DEU students showed lower favorable expectations and higher unfavorable expectations than other university students (Redish et al., 1998). However, there were small differences between the mean favorable expectations of all DEU students and the OSU students in the concepts cluster and between the mean favorable expectations of DEU PBL students and the UMCP students in the reality link cluster. DEU groups had higher favorable scores than the OSU students in the concepts cluster and DEU PBL group had higher favorable scores than the UMCP students in the reality link cluster. In addition, DEU PBL students showed similar favorable agreement in the pre- (65%) and post- (51%) scores with the OSU students (pre: 65%, post: 54%) in the reality link cluster. In all the other clusters, DEU students had lower favorable expectations than those of other groups in previous research (Redish et al., 1998).

Figure 1 presents agree – disagree plot (following the presentation line of Redish et al.) for DEU PBL group. Traditional group responses to all dimensions are displayed in Figure 2 in the form of agree-disagree plot. Expert responses were shown in both figures by "+" sign. Initial MPEX results of PBL and traditional group students differ substantially from the expert results. For each MPEX cluster, the base of the arrow represents the pre-test favorable and unfavorable percentages, while the tip of the arrow represents the post-test percentages. Arrows point to the direction of change from the pre to post deployment of the MPEX. As the arrows present, PBL group favorable scores decreased substantially and their unfavorable scores have increased except for the concepts cluster. For every cluster, a paired-samples t-test reveals the pre–post changes in the percentage of favorable responses to be statistically significant to $p < 0.05$, except for the concepts cluster. In addition, for the concepts cluster BPL group unfavorable scores have decreased significantly in the post application. For all the other clusters, PBL group unfavorable scores have increased with the highest being in the coherence cluster. These results suggest that PBL students' expectations and beliefs about physics deteriorated after one semester of instruction. However, their beliefs about the content of physics knowledge did not change and unfavorable views decreased which means that students in PBL group stress the understanding of the underlying ideas and concepts, rather than the memorization and usage of formulas more than they did at the beginning of the semester. This finding displays the characteristics of PBL approach which lets students search, work together, analyze concepts, solve problems, and learn how to learn. In the context of this study, students had

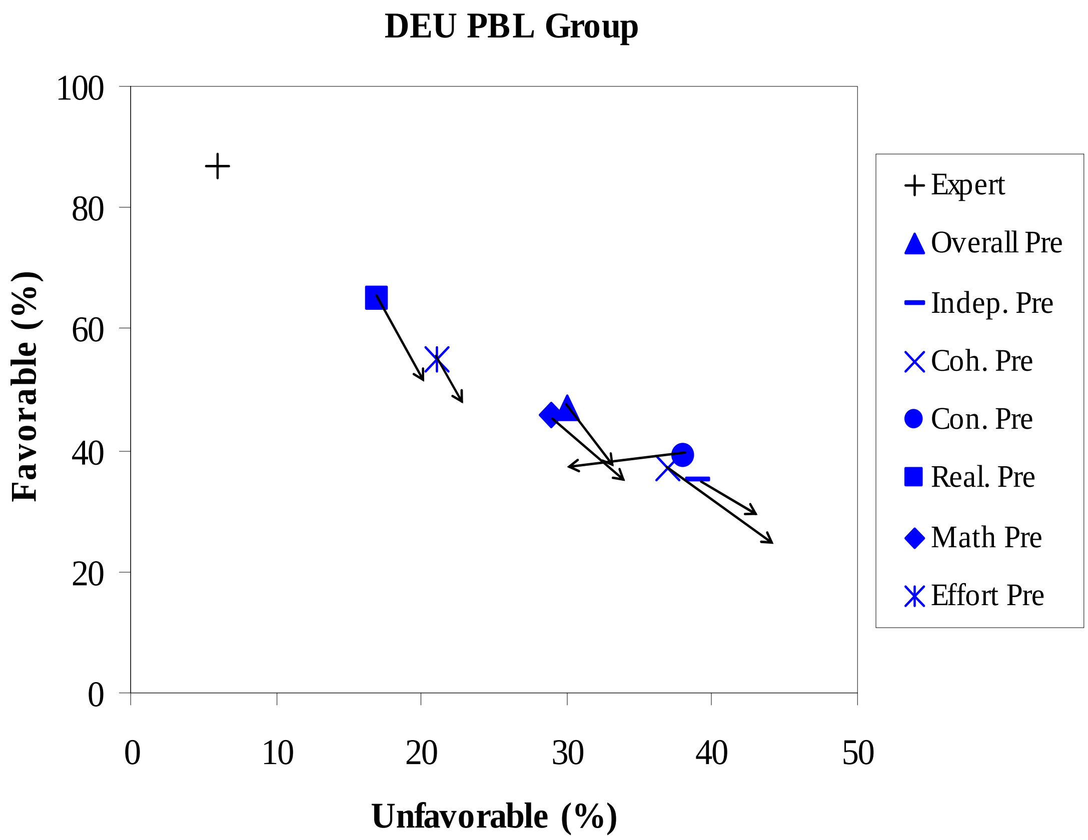

Figure 1. Agree-disagree plot for DEU PBL group MPEX results.

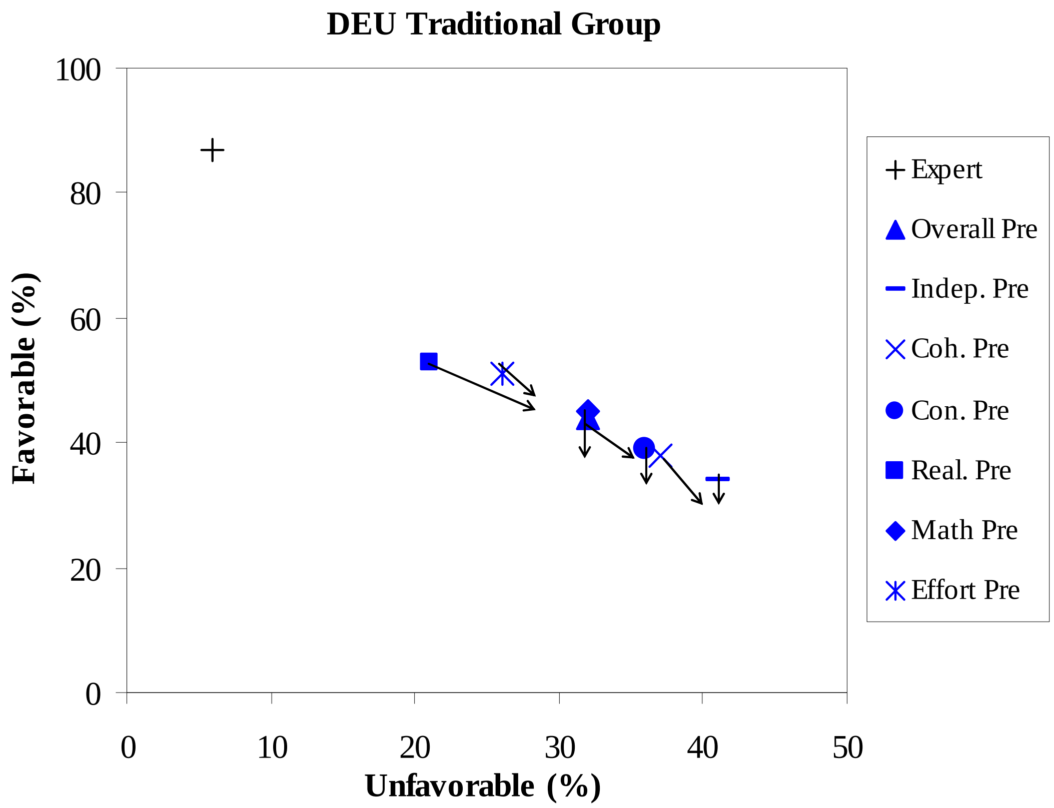

Figure 2. Agree-disagree plot for DEU traditional group MPEX results.

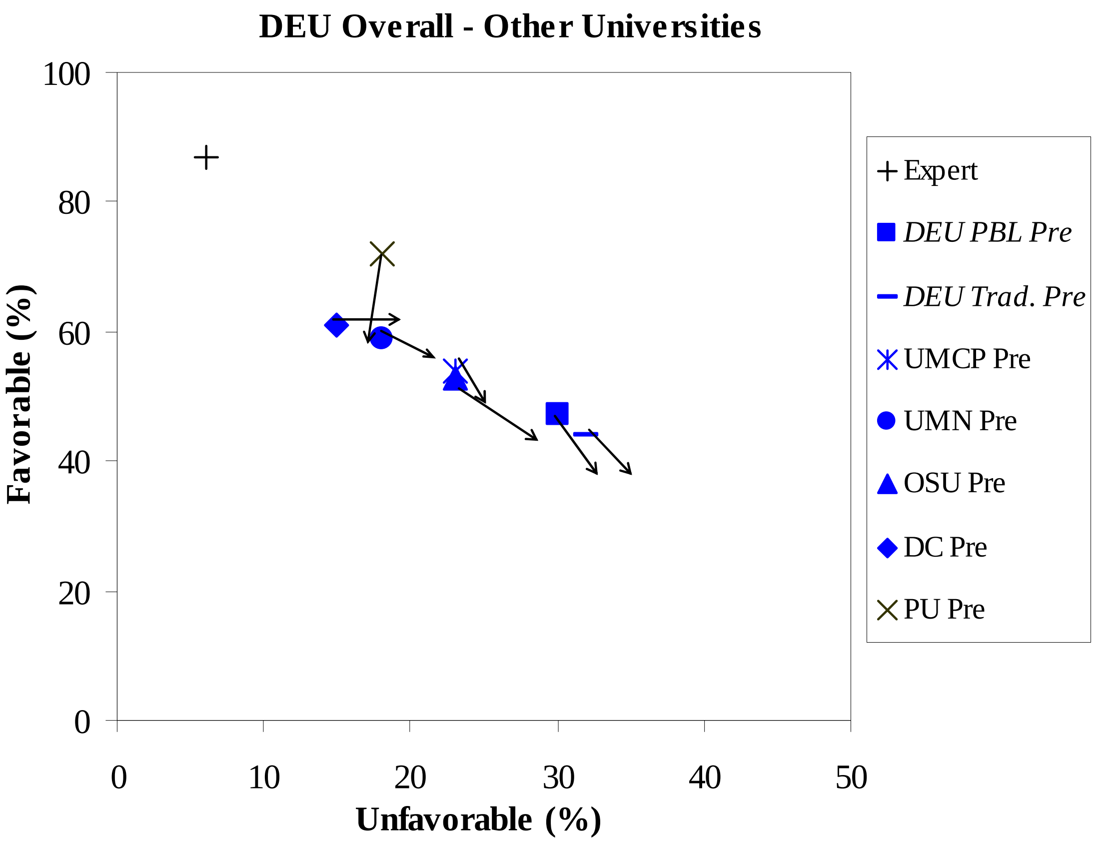

Figure 3. Agree-disagree plot for all students' MPEX results including other universities reported in Redish et al. (1998) and Ornek et al. (2008).

to search and learn the concepts required for solving the problem at hand, thus, they had a chance to understand the underlying ideas and concepts rather than just to memorize what is given by the instructors.

As seen in Figure 2, traditional students showed slight decrease in their favorable responses in the independence, concepts, and effort clusters. For the other clusters, a paired samples t-test reveals the pre–post changes in the percentage of favorable responses to be statistically significant to $p < 0.05$. The only significant increase in their unfavorable scores occurred in the reality link cluster with slight or no change in all the other clusters. Both PBL and traditional students' unfavorable responses are substantially high and very similar to each other in both pre and post results. These results, though very low in percent agreement to expert views, suggest that traditional students' epistemological beliefs and expectations about physics deteriorated after one semester of instruction. However, their unfavorable beliefs about learning physics, the content of physics knowledge, and the role of mathematics in learning physics did not change after one semester of traditional instruction.

The overall MPEX results for different universities and DEU PBL and traditional groups are presented in Figure 3. The largest decrease in the favorable scores was in PU (Ornek et al., 2008) students' scores, though they had the largest percent agreement to expert views at the beginning of the semester. Unfavorable scores of all groups have increased except for PU students. DEU PBL and traditional group overall scores have decreased more than all the other universities except for PU. In addition, DEU traditional group favorable scores have decreased less than PBL student scores. One common feature of DEU and other universities was that similar to the results reported in Redish et al. (1998) the overall expectation scores of DEU students deteriorated after one semester.

CONCLUSION

The results of this study suggest that modular-based active learning approach (problem-based learning) employed at DEU since 2002 resulted an average deterioration in student expectations and beliefs about introductory physics. The purpose of this study was to investigate university students' expectations and beliefs in an introductory calculus-based physics course. The study has also compared expectations and beliefs of PBL and traditional group students. The overall scores (i.e., percent agreement with the expert group) of PBL students (Overall 38%) and traditional students (Overall 38%) on the MPEX clusters were very low compared to expert scores. The results suggest that research-based instructional technique, PBL, was not at all different from traditional instruction in influencing students' expectations and beliefs about physics and physics learning at DEU. One of the possible explanations of low scores of both groups might be students' negative feelings about physics and the second semester physics course. In addition, it was revealed that they thought they could not do physics and that they were really concerned about their grades. PBL group had more severe grade concerns, because, to pass the course they need a total average grade of 70 out of 100. 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 PBL group students since as observed by the author, in one department, there were several repeats and several (25 out of 85) students were expected to fail the course in that semester. In addition to grade concerns, it is thought that heavy course loads of PBL students might have influenced their beliefs about the course. As witnessed by the author, PBL students had very limited spare time for individual studies. They spent a great deal of time and showed a considerable effort on the project which constitutes 5% of their final grade.

Perhaps the most significant limiting factor in this study was that PBL approach might have led students to feel anxious about the approach and also caused grade concerns for students. 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 frequently complained about the system at DEU 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 indicate some important points one of which is the way PBL approach is applied at DEU in freshman engineering classes. The reader should be reminded that new and innovative approaches are new to Turkish students, and probably a sudden and complete change in instructional techniques created a shock for them in the freshman year.

IMPLICATIONS

The influences of beliefs on student learning have been documented in the literature for more than two decades. Despite several limitations, this study has been able to add to the literature in this area. The results of the study may have some implications for physics teaching in engineering faculties and for further research on student expectations and beliefs about physics.

DEU students in this study displayed very low agreement to expert views in all clusters of the MPEX. This would probably affect their attitudes, study habits, motivation, and thus 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. We may start doing this by getting to know our students' strengths and difficulties; planning and using interactive lectures to create effective resources; and designing reflective homework and exam questions and planning discussions with peers and faculty to let students consider their attitudes and beliefs about learning.

DEU engineering faculty students should be investigated further to find reasons of failings and low expectation scores. Structured, in depth interviews with students and faculty members of the departments employing PBL approach could yield valuable information for improving the effect of the method as well as student success in engineering physics.

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