

Full Length Research Paper

The effects of problem-based learning on pre-service teachers' achievement, approaches and attitudes towards learning physics

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The purpose of this study was to evaluate the effects of the Problem Based Learning (PBL) method on students' achievement in and approaches and attitudes towards an introductory physics course. With the control group, a quasi-experimental pretest–posttest design was used. A total of 25 freshman students majoring in mathematics teaching in a five-year pre-service teacher education program in Turkey participated. There were one control group and one experimental group; namely, the PBL group. Pre-service teachers were randomly assigned to either one of the two groups: The PBL group ($n = 12$), who received physics instruction in accordance with the PBL format, or a control group ($n = 13$), who received physics instruction in line with traditional teaching methods. Data were collected via the pre and post administration of the Magnetism Test (MT), the Approaches to Learning Scale (ALS), and the Scale of Attitudes towards Physics (SAP). The results indicated that the problem-based learning method not only encouraged the students' deep approach to learning, but also improved interest (a component of attitude) towards the physics course. The results also signaled that PBL-based physics instruction impacted the students' achievement in physics positively. The paper ends with some implications for the instruction of physics.

Key words: Problem-based learning, physics education, achievement, attitude, approaches to learning.

INTRODUCTION

The fact that traditional methods of education cannot serve the needs and wants of today's students, the need for lifelong learning, and the latest developments in teaching-learning have altogether paved the way to the emergence of new approaches in teaching. One of these is Problem-Based Learning, which is one of the best examples of modern constructivist learning environments (Savery and Duffy, 1995). Problem-based learning (PBL) was first implemented in medical education by McMaster University, Canada in the 1960s (Barrows and Tamblyn, 1980). Soon, this method was adopted at Maastricht University in Holland and other places in Europe as well (Sezgin Selçuk and Şahin, 2008).

PBL is described as a constructivist teaching model based on the assumption that learning is a product of cognitive and social interactions originating in a problem-focused environment (Greeno et al., 1996). The theoretical philosophy of this approach is derived from John Dewey and discovery learning (Rhem, 1998).

Fundamentally, PBL is an educational method in which students develop critical thinking and problem-solving skills in addition to developing an understanding of grasping essential concepts through the analysis of real-life problems (Duch, 1995). Learning takes place throughout a process where learners try to solve real-life problems in groups of seven to eight people. Barrows (1996) labels the main characteristics of PBL as follows: (a) Learning is student-centered, (b) Learning takes shape in small groups of students, (c) Teachers should act as moderator and facilitator, (d) The problems provide motivation for learning and organizational focus, (e) Problems provide the basis for the advance in clinical problem-solving skills, (f) Self-directed learning aids the acquisition of new information.

Advocates of PBL have also stated that besides equipping students with knowledge, this approach could also be employed to improve their problem-solving skills, critical and creative thinking abilities, lifelong learning

aptitudes, communication skills, group cooperation, adaptation to change and self-evaluation abilities (Albanese and Mitchell, 1993; Dolmans and Schmidt, 1996). Moreover, it has been expressed that PBL increases students' motivation toward learning (Albanese and Mitchell 1993), and enables them to build a far more positive approach to learning (Coles, 1985; Newble and Clarke, 1986).

Even though there are positive results from the implementation of the PBL method, it was apparent that both teachers and students faced some difficulties. Ngeow and Kong (2001) identified that as the PBL approach requires students to adopt active learning strategies and become more self-directed in their learning, some students face difficulties in adapting into critical thinkers. Difficulties also extend to instructors who have problems in facilitating discussion, coaching, challenging students to think and managing group work.

Furthermore, when the PBL method is adopted, it requires a greater number of staff to be involved in tutoring and essentially more staff development particularly focusing on facilitation and management of group dynamics (including dysfunctional groups) (Wood, 2003). Goodnough (2003) also identified that the use of modified PBL with large groups was hard due to the difficulty in ensuring that groups functioned successfully.

The comments reflect some concerns about working in groups within PBL instruction. These refer to various aspects of group dynamics like dependence on other members and inconformity within groups. Due to time constraints, information is not always properly shared or fully discussed. There can often be resentment because some group members take on more responsibility than others. Some students indicate discomfort with the process in their comments that there is not enough direction; they request more feedback on the success of their efforts or are uncertain if they have covered all the relevant areas (Boud and Feletti, 1997).

This article is about the effects of the PBL method on students' academic achievement, approaches to learning and attitudes towards learning. The relationship between those students' outcomes and the PBL method itself will be discussed further.

Academic achievement, learning approaches and attitudes towards learning and PBL

The researchers who have adopted the PBL approach and have applied it to various disciplines have realized that PBL has important cognitive learning outcomes such as course achievement, retention, problem solving skills, learning strategies, approaches to learning (Berkel and Dolmans, 2006; Chin and Chia, 2004).

It is widely believed that problem-based tutorial groups positively influence learning. In studies focusing on the cognitive effects of small group PBL, activation of prior

knowledge, recall of information, causal reasoning or theory building, cognitive conflicts leading to conceptual change and collaborative learning construction have been identified as taking place during tutorials (Dolmans and Schmidt, 2006). In PBL, students follow a certain pattern of exploration which begins with the consideration of a problem consisting of occurrences needing explanations. During discussion with peers in tutorial groups, students try to identify the fundamental principles or processes. Here, students stimulate their existing knowledge and find that they may need to undertake further study in certain areas. As a result of this, students research the necessary points and then discuss their findings and difficulties within their groups.

Advocates of PBL claim that the discussions held in tutorial groups contribute to students' cognitive learning positively (Dolmans et al., 2001). Moreover, PBL impacts students' motivation for learning optimistically as well. A certain cognitive process (that is, epistemic curiosity or intrinsic interest in subject matter) is facilitated by the process entailed in PBL (Schmidt, 1993; De Volder et al., 1986). By discussing subject matter in tutorial groups, students become engaged which in turn influences their inherent interest in the subject matter (Dolmans and Schmidt, 1996). In other words, students' intrinsic interest motivates them to develop a full understanding of all of the components needed for its solution (Groves, 2005). Consequently, it can be postulated that these cognitive and motivational benefits of PBL definitely have a positive resultant impact on academic achievement.

In addition to academic achievement, another cognitive variable examined in this study is students' approaches to learning. A learning approach, a concept with two components, includes the students' motives for learning and the use of appropriate learning strategies. "Motive" points out why students want to learn; while, "learning strategy" indicates how they do it (Zhang, 2000). When the literature regarding "approaches to learning" was reviewed, it was revealed that it was first Marton and Säljö (1976) who mentioned deep and surface learning in their study.

Marton and Säljö analyzed the behaviors of college students throughout the learning process, and categorized them into two groups as "deep learning approach" and "surface learning approach." Below one can read the descriptive characteristics of "learning approaches" (Byrne et al., 2002):

Deep approach

Being enthusiastic about learning, being in intense interaction with the subject matter, establishing a meaningful correlation between previous knowledge and new, associating concepts with daily experiences, interrelation of the events with their results and considering the rationale behind the discussion.

Surface approach

The desire to accomplish what the task requires, memorization of the necessary knowledge before exams, failure to distinguish principles from examples, the regard of learning as an external imposition, focusing on the elements individually without integrity, not conceiving the objectives and/or strategies.

In summary, while the “deep learning approach” is a modernist method where the learner actively participates in the learning task so as to reshape the knowledge provided, the “surface learning approach” is a traditional one where the learner is completely passive waiting for the teacher to transfer the information directly (Dart et al., 2000). Some students favor the “deep learning approach” while others favor the “surface learning approach”. Their preferences might change according their personalities (Biggs, 1999). What’s more, some students favor the “strategic approach”. This approach describes the actions of students who are primarily concerned with achieving the highest possible grades. These students use a combination of deep and surface approaches, as appropriate, and have a competitive and professional motivation (Byrne et al., 2002). As this approach is considered to be more of a studying approach than a learning one (Morgan, 1993), it is not included in this research.

There are research that have proved that students might get influenced by their perceptions of the learning environment when selecting an approach to learning (Trigwell et al., 1999; Mayya et al., 2004). Ramsden and Entwistle (1981) reported that teaching characteristics such as the methods of learning employed in classes, the teacher’s enthusiasm, the level of the knowledge being taught and the pace of progression have a great impact on approaches to learning. Margetson (1994) noted that traditional methods of teaching encourage the learner to adopt the “surface learning approach”; and that it is the PBL method that integrates the four vital elements of the “deep learning approach”: A well-structured knowledge database, active learning, interaction through cooperation and the conditions planned in a way to increase intrinsic motivation.

When the literature for PBL is reviewed, it is apparent that the majority of the studies conducted about PBL focused on students’ acquisition of knowledge and skills rather than the analysis of various approaches to learning. The results of the primary research on this subject matter verify that PBL does have a significant role in students’ approaches to learning. Coles (1985), Newble and Clark (1986) confirmed that the students receiving training in PBL groups have more of a tendency to deep and multipronged learning when compared with those educated with traditional methods who have a bigger tendency to copy the knowledge. In a study, Blumberg and Michael (1992) noticed that PBL students use course books and reference books more often than

non-PBL students who entirely stick to lecture notes. Tiwaria et al. (2006) carried out a research to show to what extent the PBL method shapes nursing students’ approaches to learning. This was diagnosed through the use of a revised “Study Process Questionnaire” (R-SPQ-2F) with two factors. The analysis results demonstrated that with the “deep learning approach”, the students scored way higher in the posttest when compared with the scores they got in the pretest: Whereas, there was no significant change in their scores obtained through the “surface learning approach.” Furthermore, a study by Mok et al. (2009) indicated that the learning approaches of the students who attended a speech-language program designed in accordance with the PBL method through the exploitation of a revised “Study Process Questionnaire” with two factors. The students’ “deep learning scores” were far higher than their “surface learning scores”. In addition, the students educated with the PBL method recorded an important increase both in their “deep learning” and “surface learning” scores. Plus, while the successful students in PBL tests showed a stronger deep learning approach in comparison with the students educated with surface learning approach, there were slight differences between the “deep” and “surface” learning approaches of the ones who failed those tests.

According to the findings of many PBL studies carried out on medical education, students’ attitudes towards learning have changed, and PBL-students were more content with the learning process than the non-PBL students. To exemplify, Albanese and Mitchell (1993) reported in their study that the medical students who experienced the PBL method were more participative in the activities and that they found those activities harder but more fruitful than non-PBL medical students. Moore-West et al. (1989) stated that the PBL-students commented that the learning environment was more constructive and the lessons were more meaningful and flexible. In similar research (de Vries et al., 1989), it was described that the students who experienced the PBL method developed a more positive attitude towards the instructional environment, and enjoyed the whole learning process better when compared to the ones educated with conventional methods of teaching. On the other hand, it was noted that non-PBL students found traditional methods of teaching boring and irrelevant.

The literature demonstrates that students can benefit from PBL to improve their attitudes towards learning about their subject fields (Bridges and Hallinger, 1991; Pincus, 1995). To illustrate, Kaufman and Mann (1997) compared the attitudes of medical students educated with problem-based program and traditional course-based program towards basic sciences. After the study, they came to the conclusion that the ones in the PBL program had a more positive approach in comparison to the ones in the conventional program. In his study, Diggs (1997) explained that the PBL method had a very constructive influence on science students’ opinions about science

studies; and added that this practice allowed them to grasp science better. In another study, Akinoglu and Tandoğan (2007) expressed that the PBL method affected elementary school pupils' feelings about science class in a positive way, and observed that it improved their academic success and learning of the related concepts. Similar data regarding attitudes have been detected in PBL studies conducted in different disciplines such as mathematics and social sciences (Cantürk-Günhan and Başer, 2008; Deveci, 2002). In addition to this, some research results claim that the PBL approach did not affect the students' attitudes towards science (Gürses et al., 2007; Liu et al., 2006; Williams et al., 1998). Surveys show that approach and learning are two interrelated variables (Alkhateeb and Hammoudi, 2006; Svirko and Mellanby, 2008). For instance, Alkhateeb and Hammoudi (2006) analyzed the correlation between college students' attitudes towards mathematics and how much they learned. The outcomes of the study indicated a negative correlation between the students' scores for their attitude towards mathematics and their surface learning approach scores; on the other hand, it showed a positive correlation between their attitude scores and deep learning approach scores. Svirko and Mellanby (2008) measured the sophomore medical students' approaches to learning in Computer-aided Learning (CAL) class by using a revised two-factor Study Process Questionnaire, R-SPQ-2F, and examined the relationship among the students' attitudes towards this specific course. It was concluded that enjoyment in the course, appropriateness of the information included, and ease of understanding the course were all associated with a deeper approach.

Today, the problem-based learning approach is used in various fields of education, mainly in medical education (Barrows, 1996), engineering (Nopiah et al., 2009), law (Moust, 1998), in-service teacher training (Sezgin Selçuk and Sahin, 2008) and science education (Ram, 1999; Sungur et al., 2006) besides at senior high school level (Barrows and Kelson, 1993). Moreover, it is becoming more and more popular. Although the literature on PBL supports the benefits and effectiveness of this approach in various fields, it has been noted that there are few studies concerning physics education through PBL (Duch, 1996; Fasce et al., 2001; Raine and Collett, 2003; van Kampen et al., 2004; Sezgin Selçuk and Tarakçı, 2007; Sahin, 2010; Sahin and Yorek, 2009; Williams, 2001). The scope of this study is the discipline of physics; and the study is based on related studies on PBL.

Problem-based learning in physics

PBL has a large amount of literature, and as mentioned above, there is not much research on physics education using PBL method. This type of teaching in physics has a ten-year history or so. The first study on this subject

matter that was found belongs to Duch (1996). In her survey, Duch obtained some evidence that learning in groups, and establishing a relationship with real-life applications assists learners during a general physics course as well as using knowledge for the right purposes. Fasce et al. (2001) divided the freshman medical students in physics class into two groups as "traditional learning group" and "problem-based learning group." According to the outcomes of the study, although there was no significant difference between the cognitive performances of the two groups, scientists reported that "PBL-students" were more satisfied both with the teaching method and the learning process in comparison with the "traditional-learning group students." Van Kampen et al. (2004) taught the thermal physics module, they developed in a course-based program, but using the PBL technique. All the students involved in the study reported positive feedback about the PBL implementation, and performed better in exams than they used to before the use of the PBL method. In a PBL course in introductory physics, Williams (2001) reported that the grades that the students scored in the Force Concept Inventory in the Fundamentals of Physics class conducted with the PBL Method doubled the ones they got in the classes carried out with traditional methods. Sahin (2010) examined the beliefs of PBL-college students about physics in general and learning physics in addition to their conceptual understanding of some of the subjects regarding Newtonian mechanics. Two groups of students who were enrolled in the physics course at the Faculty of Engineering at a Turkish University participated in this study; one group was trained with the PBL Method and the other with conventional methods of teaching. In this research, data were collected through the Colorado Learning Attitudes about Science Survey, CLASS, FCI and pretest-posttest, time-based and group-based comparison analysis was made. The results of the analysis demonstrated that PBL-students gained significantly better conceptual learning skills than the students in the traditional-learning group. However, this study also showed that the PBL approach does not have any influence on students' beliefs about learning physics. Sahin and Yorek (2009) compared students' expectations about physics and physics learning and achievement in introductory physics classes taught by traditional and problem-based learning (PBL) approaches. Student expectations were measured using the Maryland Physics Expectations Survey (MPEX) and physics achievement data were obtained from students' end-of-semester physics grades. Results indicated that groups did not differ in their average MPEX scores and physics achievement as a result of one semester of instruction. Significant differences were determined in some components of the MPEX with respect to instruction type. Specifically, PBL students obtained significantly higher scores (more expert-like) on beliefs about the connection between physics and reality than the traditional students.

PURPOSE AND SIGNIFICANCE OF THE STUDY

In brief, it is obvious that problem-based learning method in physics has been proved helpful with improving students' conceptual learning, overall success, satisfaction they get from learning, performance in exams, and their attitudes towards learning. In spite of the limited number of PBL-based physics education research, as far as is known, it has not been used throughout the student teachers' pre-service training process (in physics instruction). Furthermore, there are only a small number of studies concerning students' approaches to learning physics (Dickie, 2003; Nguyen, 1998; Prosser and Millar, 1989; Prosser et al., 1996; Sezgin Selçuk et al., 2007). It has been observed that those studies focus on determining approaches of students, who were educated with traditional methods, to learning physics, not on the effects of active learning methods such as PBL.

The purpose of this specific study, which was planned in consideration of these disadvantages, is to determine the effects of teaching physics with a problem-based method on the approaches of student teachers' to learning physics, and compare its outcomes with the effects of learning physics by conventional methods of teaching. Throughout the research, the following problems are answered:

1. Does problem-based learning have an effect on pre-service teachers' achievement in physics?
2. Does problem-based learning have an effect on pre-service teachers' approaches to learning physics?
3. Does problem-based learning have an effect on pre-service teachers' attitudes towards physics?

It is strongly believed that the results of this study will definitely contribute not only to the literature on PBL and physics education, but also to the syllabi to be prepared at colleges in order to increase efficiency of classes. In addition to this, the fact that this study has been conducted at a faculty where pre-service teachers are educated, in a physics course where the rate of success is quite low (Sezgin Selçuk, 2004), and also on magnetism which includes several abstract concepts definitely enhances the significance of the research.

MATERIALS AND METHODS

In this study, the pretest/posttest quasi-experimental method with a control group was used. There was one control group (or traditional instruction group) and one experimental group (Problem-based learning group or PBL group).

Subjects

The subjects of this study were 25 first-year pre-service teachers (female = 15, male = 10) who were enrolled in the Department of Secondary Mathematics Education (SME) at Dokuz Eylül University

which is a Turkish medium university in Izmir, a large city in Turkey. Physics is compulsory in this department, and it is offered in two successive semesters (fall and spring) as Physics I (4 credits) and Physics II (4 credits) at the introductory level as calculus-based. Physics I focuses on mechanics concepts and Physics II focuses on electricity and magnetism concepts.

The students were randomly assigned to the PBL and control groups, consisting of 12 and 13 students respectively. In the first grouping, students were randomly assigned to the two groups (that is, PBL and control groups) by looking at their success rates in the physics course (that is, Physics I scores) and their gender. A reasonable balance between the two groups was achieved. Besides this, PBL groups (subdivided into two small permanent groups of 6 students) were formed using the method of heterogeneous grouping (according to their success in physics and verbal interaction skills). As suggested by a number of researchers heterogeneous grouping was used because of its positive effects on group performance and communication skills (Wang et al., 2007). The mean ages of the students in the PBL group and the control group were 18 years and 18.5 years, respectively. All of the students in both groups (PBL and control) completed 3 years of general high school instruction (in Turkish high schools) and they were familiar with the traditional methods of teaching. The students had not experienced the PBL method before the experimental treatment. The distribution of subjects with respect to gender and groups is presented in Table 1.

Data collection instruments

The research data have been collected by using "The Magnetism Test", "The Approaches to Learning Scale" and "The Scale of Attitudes towards Physics." Below, one can find detailed information about these measuring instruments.

The magnetism test (MT)

Pre-service teachers' achievement in magnetism was measured using the Magnetism Test (MT). The instrument, containing 20 five-option, multiple-choice questions, was developed by the researcher. For this study, some important topics concerning magnetism were selected from the textbook "Physics for Scientists and Engineers with Modern Physics 2" by Serway and Beichner (2000). The topics included in the test were as follows: Magnetic Field and Magnetic Forces, Motion of Charged Particles in a Magnetic Field, Magnetic Force on a Current, Force between Parallel Conductors, Biot-Savart and Ampère's Law, Magnetic Flux, Electromagnetic Induction, Faraday's Law, Lenz's Law, Motional Electromotive Force. The test was intended to determine the knowledge of students related to the fundamental concepts, and their skills on recalling the relationships between concepts, and applying them to both semi-qualitative and quantitative problems. So as to make the test content wise a valid one, twenty-five questions were prepared in the initial draft to check the learning objectives. Four faculty members from Dokuz Eylül University, who have taught Physics II before, scrutinized those questions. The initial version of the test was prepared in line with their suggestions, and was pilot-tested on a small group of students including 30 people. After that, considering the feedback, the test was revised. The revised version of the test was piloted on a group of 120 students who had taken Physics II before. In the view of the obtained data, test and items have been analyzed. The item difficulty index and item discrimination index of each item have been computed. In a way not to decrease the content validity, five of the items whose item discrimination index are below 0.30 have been removed from the test. The discrimination indexes of the items included in the test vary between 0.30 and 0.60. The Kuder-

Table 1. The distribution of subjects with respect to gender and groups.

Gender	PBLG (1)	PBLG (2)	CG	Total
	n (%)	n (%)	n (%)	
Female	4(67)	3(50)	8(62)	15
Male	2(33)	3(50)	5(38)	10
Total	6(24)	6(24)	13(52)	25

Note. PBLG: Problem-Based Learning Group, CG: Control Group, Values in parentheses are percentage of subjects in groups.

Richardson (KR-20) reliability coefficient of the test was found to be 0.82. An example of a question from MT is shown in the Appendix 1.

The approaches to learning scale (ALS)

Students' approaches to learning in physics course have been clarified by using the Approaches to Learning Scale (ALS), which has been developed by Ellez and Sezgin (2002) specifically for university students. The scale can be adapted for any course at university level. It is a 5 point Likert scale composed of 30 items has the options of "Strongly Agree", "Agree", "Undecided", "Disagree", "Strongly Disagree". The Cronbach Alpha reliability coefficient of the scale is 0.81, and the items on the scale have been grouped under two perspectives: "Deep Approach (DA)" and "Surface Approach (SA)". In "Deep Approach (DA)", there are 19 items; and in "Surface Approach (SA)", there are 11. The items on the scale start a "Strongly Agree" and are graded as 5, 4, 3, 2, 1. The reliability coefficients of the sub-scales of the scale are 0.82 and 0.76 respectively. In "Deep Approach (DA)", there are items that include "I learn to learn," "I learn by doing research using different sources"; in "Surface Approach (SA)"; however, there are items that include "I learn enough to pass the class," "I prefer memorizing when studying."

The scale of attitudes towards physics (SAP)

To determine students' attitudes towards physics course, we used SAP which was developed by Sezgin Selçuk et al. (2004). It comprises of 40 items. SAP is a 5 point Likert scale (ranging from Highly Applicable, Applicable, Neutral, Inapplicable, and Highly Inapplicable). 22 of the items reflect positive attitude; whereas 18 reflect negative attitude. It is a two-factor scale whose Cronbach Alfa reliability coefficient is 0.97.

Each item's factor loading was above 0.40. The percent of total variance explained by two factors was 53.4%. The names of the factors are "sense of interest" and "sense of care" respectively. "Sense of interest" is made up of 25 items, and its reliability coefficient is 0.96. Here, one can find items that have expressions like "having an interest in physics" and "enjoying physics". Some example items to "sense of interest" are: "I am interested in everything related to physics," "I am not interested in physics except for when I am in class". The coefficient alpha of "sense of care" is 0.90, and is made up of 15 items.

Here, there are expressions like "I think physics is important", "I think physics is a course that needs to be learned". The minimum score acquired in the scale is 40, whereas the maximum score is 200.

Intervention instruments

The Turkish translation of the textbook Physics for Scientists and Engineers with Modern Physics 2 by Serway and Beichner (2000) was used as the textbook in the control group. In the PBL group, problem-based learning scenario teaching material called "TV Box" was used. The PBL scenario has been organized in two ways as "teacher's" and "student's copy". The tutor copy is a written copy of all of the steps a student needs to take during the scenario (that is, defining the problem, summarizing, producing hypothesis related to the problem, determining the learning goals, reaching new information by researching, doing numerical analysis of the problem if necessary) (see Appendix 2). In the student copy, the previously mentioned parts were left empty for the students to complete. In the beginning of the PBL sessions, the copies of the scenarios were distributed to each student and tutor. During the sessions, small whiteboards and board markers were used by the students.

Procedure

The study was conducted during the spring semester in 2008-2009 academic year in the General Physics II course (which focuses on electricity and magnetism concepts). The duration of the study was four weeks (16 hours of lecture time) from April to May. Both groups' achievement in magnetism, attitudes towards the physics course itself, and approaches to learning physics have been evaluated both before and after the study. The independent variable was the intervention (the PBL and the traditional instruction). The dependent variables were posttest achievement, approaches to learning and attitude scores. To examine the implementation of PBL, some key topics in magnetism (Magnetic Field and Magnetic Forces, Motion of Charged Particles in a Magnetic Field, Magnetic Force on a Current, Force between Parallel Conductors, Biot- Savart and Ampère's Law, Magnetic Flux, Electromagnetic Induction, Faraday's Law, Lenz's Law, Motional Electromotive Force) were chosen for the study. This study started immediately after (that is, after the pretest) teaching (with traditional instruction in whole-class format) fundamental electric topics (electrostatic forces, electric fields, electric potentials, capacitors and dielectrics, direct-current circuits). During a ninety-minute lesson in the PBL group, a sample scenario whose topic was different from the ones targeted in the research (the law of gravity and the movement of satellites) was gone through by the teacher and the students. Then, the students were informed about how problem-based learning methods are used (that is, phases of problem-solving process). In the control group, the same topics were covered at the same time using the traditional instruction method. During the research, the PBL group (subdivided into two small-groups of 6 students) received physics instruction with problem-based learning format (that is, using a PBL scenario named TV Box), whereas, the control group received physics instruction using a lecture-based format. Instruction in the PBL group was module-based (that is, a module of 4 weeks).

The scenarios in the module which consisted of four PBL sessions were selected from the course book the control group used. The magnetism topics previously mentioned were covered in the scenarios and were prepared by the first researcher (with three years of experience in PBL and fourteen years of expertise in the field of physics teaching). The scenario was revised by an instructor (with ten years of experiences in the field of physics education). Consecutive topics within a scenario were linked to each other carefully. The scenario was prepared for students both to learn by searching for information and to implement what they learnt (that is, both qualitative and quantitative problem-solving) and included complex and real-world problems (that is, ill-defined or open-ended). In the control group, about 90% of the topics taught using traditional methods were adapted to the scenario format. The rest

of the topics were covered during the sessions by the tutors using open-ended questions and the students brainstormed about them. Teaching in the small PBL groups was done in two separate classrooms with a permanent tutor (that is, the author and a lecturer helper) in each of them simultaneously (for four consecutive lecture hours) in a face-to-face setting. The PBL tutors acted as cognitive coaches (guiding, probing, and supporting students' initiatives). In the first three PBL sessions (over a three week period), students were asked to solve two or three new problems (qualitative and/or quantitative problems each connected to each other) working together.

In the last PBL session (in the fourth week), the scenario consisted of one part and it required the solution of the first problem (that is, the main problem presented in the first PBL session and Part 1) and revision of all the information learnt. In the control group, the topics were presented in traditional lecture format (four lecture hours each week) by the author. The numerical problems solved during the PBL sessions were solved in the traditional problem solving format in the control group.

Data analysis

The data obtained from "The Scale of Attitudes towards Physics" and "The Approaches to Learning Scale" have been analyzed by using SPSS 13.0 statistical analysis program. Frequencies (n), percentages (%), means (M), medians (MD) and standard deviations (SD) were calculated.

We cannot assume that the dependent variables had normal distribution due to the small number of the sample in each group: n_1 and $n_2 < 20$. Hence, non-parametric tests were required to be used during the analysis of the data (Pett, 1997). The non-parametric statistical methods, the Mann-Whitney U test and the Wilcoxon Signed-Rank test, were conducted. Nonparametric effect size indices (Cliff's d) was calculated for Mann-Whitney U tests as proposed by Cliff (1993). We used an alpha level of 0.05 for all of the statistical tests.

RESULTS

The descriptive statistical information regarding the students' pretest and posttest scores from MT, ALS and SAP sub-scales is presented in Table 2.

The effects of PBL on students' achievement in physics

It was checked whether there was a significant difference between the PBL group and the control group students' rate of success in magnetism before and after the test. To find that out considering both their pretest and posttest scores, the Mann-Whitney U test was used with independent samples. To do that, students' mean ranks and sum of ranks have been determined in view of their Magnetism Test pretest and posttest scores. Statistically, there is no important difference between the PBL group and the control group students' pretest mean ranks regarding the Magnetism Test (Mann-Whitney $U=72.50$ $z = -0.304$, $p > 0.05$, Cliff's $d = 0.070$); however, the difference between their posttest mean ranks was extensive in favor of the PBL group (Mann-Whitney $U = 23.00$ $z = -3.008$, $p < 0.05$ two-tailed), and its effect size

is large (Cliff's $d = 0.705$).

The Wilcoxon Signed Ranks Test was used in order to test how significant the difference between the pretest and posttest median scores of the PBL group and control group students is. There has been a considerable increase in both the PBL group (from 5.00 to 16.50) and control group's magnetism test median scores (from 5 to 13.00) as it moves from pretest to posttest ($z = -3.076$, $p < 0.05$; $z = -2.950$, $p < 0.05$, respectively).

The effects of PBL on students' approaches to learning physics

It was examined whether there is a prominent difference between the approaches of students in PBL and control groups to learning physics in general, before and after the experiment. So as to see if there was a significant difference between the PBL and control groups respecting their pretest scores, a series of Mann-Whitney U tests were employed for independent samples. For this reason, the mean ranks and sums for the ranks of the students in light of the ALS sub-scale scores they received from pretests and posttests were calculated. The deviation between their approaches to learning physics has been analyzed by Mann-Whitney U test.

There is insignificant difference between the pretest mean ranks of PBL and control group students' sub-scale of "deep approach" (Mann-Whitney $U = 56.50$ $z = -1.171$, $p > 0.05$, Cliff's $d = 0.275$); whereas, there is significant difference between their posttest mean ranks (Mann-Whitney $U = 33.00$ $z = -2.454$, $p < 0.05$ two-tailed) in favor of the PBL group and the effect size is large (Cliff's $d = 0.576$). Statistically, there is a substantial difference between the surface approach pretest mean ranks of the students in both groups (Mann-Whitney $U=38.00$ $z = -2.184$, $p < 0.05$ two-tailed), and the effect size was large (Cliff's $d = 0.513$).

On the contrary, the difference between the posttest mean ranks was insignificant, and the effect size was small (Mann-Whitney $U=69.50$ $z = -0.464$, $p > 0.05$, Cliff's $d = 0.109$). The Wilcoxon Signed Ranks Test was used in order to test how significant the difference between the pretest and posttest median scores of the PBL and control group students is. There has been a considerable increase in the PBL group's deep learning approach median scores as it moves from pretest (MD=64.00) to posttest (MD = 75.00) ($z = -2.937$, $p < 0.05$); while, there has been a slight decrease between their surface learning approach median scores (from 38.50 to 30.50) ($z = -1.737$, $p > 0.05$). There has been a slight increase in the control group's deep learning approach median scores as it moves from pretest (MD = 66.00) to posttest (MD = 70.00) ($z = -0.245$, $p > 0.05$); while, there has been no difference between their surface learning approach median scores (from 33.00 to 33.00) ($z = -0.416$, $p > 0.05$).

Table 2. Descriptive statistics regarding MT, ALS and SAP scores.

Dependent variable	Pretest						Posttest						
	PBLG (n ₁ =12)			CG (n ₂ =13)			PBLG (n ₁ =12)			CG (n ₂ =13)			
	M	MD	SD	M	MD	SD	M	MD	SD	M	MD	SD	
MT	5.00	5.00	1.80	4.77	5.00	1.89	16.83	16.50	1.69	12.46	13.00	4.29	
ALS	DA	63.33	64.00	8.77	67.54	66.00	9.28	77.66	75.00	8.22	69.15	70.00	6.96
	SA	37.33	38.50	6.21	32.07	33.00	5.10	31.66	30.50	6.54	32.54	33.00	5.17
SAP	SI	73.83	71.50	15.66	75.23	74.00	15.55	91.83	96.50	15.13	76.92	73.00	18.45
	SC	48.42	46.50	9.28	52.38	50.00	6.73	52.17	52.00	10.82	51.31	50.00	8.22

Note. MT: Magnetism test,

ALS: the Approaches to Learning Scale, DA: Deep Approach, SA: Surface Approach,

SAP: The Scale of Attitudes towards Physics; SI: Sense of Interest, SC: Sense of Care.

The effects of PBL on students' attitudes towards physics course

It has been checked whether the difference between the PBL and traditional method group students' pretest and posttest scores respecting their attitudes towards physics course was an important one or not. For this reason, a series of Mann Whitney U tests have been conducted. It was realized that statistically, there has been no significant difference between the PBL students and control group students' pretest mean ranks regarding the "sense of interest" sub-scale (Mann-Whitney $U = 74.00$ $z = -0.218$, $p > 0.05$, Cliff's $d = 0.052$). However, the difference between posttest mean ranks was substantial (Mann-Whitney $U = 39.00$ $z = -2.125$, $p < 0.05$ two-tailed) and the effect size was large (Cliff's $d = 0.500$). In terms of "sense of care" on the other hand, the difference between neither the pretest nor posttest mean ranks was extensive (Mann-Whitney $U = 55.50$ $z = -1.226$, $p > 0.05$ Cliff's $d = 0.288$ and Mann-Whitney $U = 73.50$ $z = -0.246$, $p > 0.05$, Cliff's $d = 0.058$, respectively).

The Wilcoxon Signed Ranks Test was used in order to test how significant the difference between the pretest and posttest median scores of the PBL and control group students is. There has been a substantial increase in the PBL group's "sense of interest" median scores as it moves from pretest (MD = 71.50) to posttest (MD = 96.50) ($z = -3.061$, $p < 0.05$); while, there has been a slight increase between their "sense of care" median scores (from MD = 46.50 to MD = 52.00) ($z = -0.903$, $p > 0.05$).

According to the values, there has been no significant change neither between the control group's "sense of interest" nor "sense of care" sub-scale median scores as they move from pretest to posttest (for sense of interest: from 74.00 to 73.00; for sense of care: From 50.00 to 50.00) ($z = -1.791$, $p > 0.05$ and $z = -0.511$, $p > 0.05$, respectively).

DISCUSSION

The purpose of this study is to evaluate the effects of problem-based learning (PBL), on student teachers' achievement in magnetism, approaches to learning and attitudes towards physics. In the light of the analysis results, it could be deduced that PBL has impacted students' achievement, approaches to learning and attitudes towards learning physics positively in an introductory physics course. The students trained with the PBL method have developed a better "sense of interest" for physics and have also improved their "deep approaches to learning" when compared to "deep approach to learning" before the experiment. On the other hand, there was no significant difference between the scores concerning the attitudes and approaches of physics students educated with traditional methods.

The first finding of this study is consistent with the findings of PBL instruction research in different subject matters and grade levels. For instance, the research conducted on PBL revealed that PBL-based science instruction resulted in higher student achievements (Chin and Chia, 2004). Perhaps the success of the PBL model on course achievement can be attributed to the cognitive and motivational effects. Cognitive effects positively contributing to the ability of students to apply knowledge are stimulated by PBL. In addition to this, PBL enhances inherent interest (that is, motivational effects) in the subject matter (Dolmans et al., 2001).

It is believed that the acquisition and structuring of knowledge that takes place in PBL does so through certain cognitive effects. These effects have been identified as the initial analysis of the problem and activation of pre-existing knowledge through focused discussion in small groups, embellishment of prior knowledge and active processing of new information, reorganization of knowledge, contextual learning and stirring of curiosity related to the presentation of relevant

problems (Schmidt, 1993). It is thought that students' active engagement in the PBL process might have a positive impact on their learning and this in turn can enhance their success in magnetism topics.

The results we have obtained in this research show consistency with the results of other studies claiming that "problem-based learning" encourages deep learning in students (Coles, 1985; Newble and Clarke, 1986). These studies also indicate the increased use of meaningful ("deep") approaches by PBL students in relation to the material; while decreased use of reproductive ("shallow") approaches. Similar to the outcomes of other studies, PBL students have made great progress in their "deep approach", while they were on the decline with their "surface approach." The finding about the progress in "deep approach" shows a consistency with the results of the studies conducted in different fields. For instance, the studies carried out in medical education (De Volder and De Grave, 1988), nursing education (Tiwari et al., 2006) and foreign language education (Mok et al., 2009) have proved that the PBL Method led students to adopt a deeper approach to learning.

As it has been mentioned before, Margetson (1994) has stated that the elements encouraging students to adopt "deep approach to learning" (that is, well-structured database, active learning, interaction based on cooperation and conditions designed in a way to increase intrinsic motivation) are already embraced in the PBL Method. The deep approach describes the active engagement of the student with the material, leading to the full exploration of the learning material in order to reach a more profound level of personal understanding. On the other hand, the surface approach shows the use of constant memorization which is conducted in order to remember details primarily for assessment purposes (Entwistle, 2001).

Previous research shows us that student's approaches towards learning are directly affected by their academic environment in higher education departments (Entwistle and Tait, 1990). The results reveal that as well as factors like overload, students' perception of the suitability of the material, poor teaching; poor rapport with students and lack of self-management opportunity issues lead to the adoption of the "surface learning approach" (Mayya et al., 2004). In the course of the present study, while only a few students in the traditional class participated in the teaching-learning process; all the students in the PBL group were required to review the instructional material (PBL scenario), to participate actively in their learning process (developing hypothesis, summarizing what has been covered, revising previous subjects, making comments, drawing subject-related figures, solving quantitative problems) and interact with their peers and tutors. Throughout the PBL sessions, it has been observed that the students had a bigger tendency towards "deep approach learning". As a result, it is thought that students' active participation in the learning

activities carried out in the PBL class, their use of their own strategies of "deep learning" and observation of each other's study processes might have had a positive impact on their approaches to learning (that is, by encouraging a deep approach and discouraging the surface approach).

The results that have been obtained in this survey go parallel with the PBL results obtained in studies conducted in various disciplines such as medicine, science, mathematics, social sciences (e.g., Kaufman and Mann, 1997; Akinoğlu and Tandoğan, 2007, Cantürk-Günhan, 2008; Deveci 2002). It is clear from literature that problem-based learning leads to the students having a more positive outlook towards the subject matter. This can be attributed to the fact those students' perceptions alter and that their awareness of the relevance of the work increases. Moreover, they are able to compare the task of finding information and developing a solution to solving a mystery (Williams et al., 1998).

There may be several factors that may account for the present study's results. The possibility that the PBL group might have experienced novelty and this might have caused them to exhibit different attitudes should be acknowledged as a possibility in expressing the differences between the groups in dimension of "interest". The differences between the groups may be due to the PBL approach as well.

Perhaps the success of PBL on student attitudes towards the course can be attributed to the fact that the students are empowered by the teacher, and also that PBL is a student-centered teaching method. The reason why we think like that is all the observations that have been carried out during the PBL sessions, because tutors have observed that the students felt more comfortable, even the ones that never participated in traditional classes made a great effort to join group discussions, and they really enjoyed leading the whole teaching process. What is more, in other research (De Volder et al., 1986), it has been understood that the little group discussions on the way to solving problems really aroused an intrinsic interest in researching information about the topic. In brief, it is thought that students' active engagement in the learning activities carried out in the PBL class might have had a positive impact on their feelings about learning (that is, the notion of being responsible for and guiding their own learning). This in turn can enhance especially their "sense of interest" towards physics course.

Although the correlation between approaches and attitudes towards learning have not been examined in this study, when the information we have got concerning their approaches (that is, having a greater tendency for deep-learning approach) and attitudes (that is, showing more interest in the course) towards learning physics is deemed as a whole, it is seen that they show consistency as the outcomes of previous study proves that students' tendency to develop a more positive attitude towards the course (liking and enjoying the course, finding it useful

and comprehensible) is totally associated with the deep approach they had taken on (Alkhateeb and Hammoudi, 2006; Svirko and Mellanby, 2008).

Although the results were positive, it was apparent that both teachers and students faced some difficulties. As the regular teaching program was continuing, it was difficult to find small classrooms and staff that had mastered the PBL method. Since the PBL students were unsure how much study to do and what information was relevant to the scenario (particularly the physics abstract concepts and laws included), the students in the PBL group asked for more guidance from the tutors than those in the control group.

Conclusion

This study provides some evidence for the positive effects of using PBL on pre-service teachers' achievement in magnetism, approaches to learning physics and their attitudes towards the physics course. In the light of the research findings, teaching physics with the PBL method rather than traditional methods has been proved to be far more effective with boosting success in magnetism as well as interest (that is, factor of attitude) in the course itself. These results suggest that the use of the PBL approach in physics instruction may foster pre-service teachers' success and deep approach to learning and improve attitudes towards physics.

The fact that the study was carried out within a regular teaching program has limitations on this study. First, there were only 25 participants who participated in the complete study. Besides, it was conducted with a very small sample group, which poses a threat to the external validity of the research. Thus, we may not be able to generalize the findings. For future research under the same theme, study validity can be strengthened through the choice of larger sampling in order to justify that the effects did not just happen by chance alone. Secondly, the time of treatment was short (4 weeks). It is recommended that longer term studies should be done to ascertain whether these results will be replicated.

Notwithstanding these limitations, this study suggests that teachers and/or educators who do not use PBL in their physics instruction programs because of time constraints but want to improve the effectiveness of their instructions, may review the potential benefits of PBL. Further research studies on physics instruction with PBL may examine the longer term instruction effects of PBL on affective student characteristics such as achievement motivation, self-efficacy beliefs, test anxiety as well as attitude. In addition to all these, in coming surveys, the impacts of PBL on students' ways of employing cognitive and metacognitive strategies might be researched, and the results might be compared with differing teaching methods such as "strategy-based instruction vs. problem-based learning". Due to the fact that the study has been conducted on a physics course, which is generally

characterized as "difficult", and specifically about magnetism that includes so many abstract concepts; and also that student teachers, who are going to educate future pupils, have participated in it and have made the study even a more significant one. It is strongly believed that bringing such active methods of education into play through the training of student teachers who will educate other students in the future will make a vast contribution to enable them to get more conscious about learning. Additionally, getting the results from these applications depends mostly on forming classrooms in accordance with PBL and staff training. Therefore, institutions burden the responsibility.

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1- What is the problem?

The TVs manufactured on that specific day was not up to the preset quality standards.

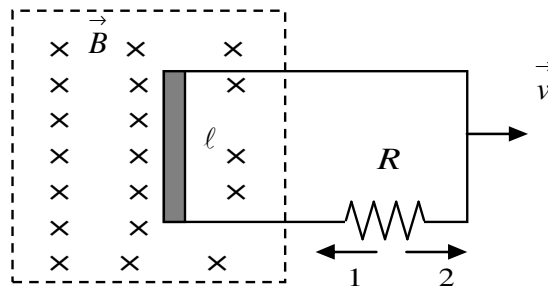
2- Write down all the possible hypothesis for the problem giving reasons.

Workers might have made some assembly mistakes.
 There might have been a production defect with the screen glasses.
 The picture tubes might not have been vacuumed well.
 There might have been a problem with the electronic components of the TVs.
 The mass production area might have been exposed to a destructive external magnetic field.

Note for tutor: By asking the students "What environmental factors might have a role in the televisions' breakdown?" the teacher can draw their attention to "magnetic field".

3- What are your suggestions for solution?

It should be diagnosed if there were assembly mistakes or not.
 It should be diagnosed if the screen glasses were defective or not.
 Picture tubes must go under vacuum control.
 The electronic components must be checked for any defects.
 It should be controlled if the mass production area has been exposed to a destructive external magnetic field or not.



- | | current intensity | direction |
|-----|--------------------------|-----------------------|
| (A) | 0.1 mA | in the direction of 1 |
| (B) | 0.3 mA | in the direction of 1 |
| (C) | 0.6 mA | in the direction of 2 |
| (D) | 0.8 mA | in the direction of 2 |
| (E) | 3 mA | in the direction of 1 |

Answer: B

Figure 1. A sample question from the magnetism test.

APPENDIX

APPENDIX 1

Question 10

The conductive frame that is inside the magnetic field which is portrait and in with a magnitude of $6 \cdot 10^{-2} \text{ wb/m}^2$.

and vertical to the area is pulled at a speed of 0,1 m/s as in Figure 1. The length of the frame is $l = 0.5 \text{ m}$, resistance is $R=10 \Omega$. So, what is the intensity and direction of the current passing through the resistance?

APPENDIX 2

(Tutor's copy including only Session 1- Part 1)

TV BOX

SESSION 1

PART 1

A group of freshman students from the Department of Electrical and Electronics Engineering, Dokuz Eylul University visit a TV production facility so as to carry out field research". While walking around in the facility, they witness the conversation between Funda, the Electronics Engineer, and the Quality Control Supervisor.

The Supervisor informs Funda that the picture quality of the televisions manufactured on that specific day was not up to the preset quality standards.