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The Effect of Problem Based Learning Approach on Conceptual Understanding in Teaching of Magnetism Topics

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Abstract

The aim of this research is to examine effect of problem based learning on conceptual understanding in teaching of magnetism topics. The research was conducted with 48 students attending of 1st class of the Department of Science Education in a state university in Turkey and a quasi-experimental, nonequivalent control group design was implemented. A concept test of magnetism topics was developed to identify students' conceptual understanding about units of "Magnetic Field and Its Effects", "Magnetic Field Sources" and "Magnetic Flux and Induction Law". The control group was taught using traditional teaching methods. The traditional approach to concept teaching consists of the following steps; giving the student the word that expresses the concept, specifying the definition of the concept and identifying and distinguishing qualities needed to understand the definition, to ensure that students find examples related and unrelated to the concepts. However, the experimental group was exposed to Problem Based Learning (PBL) activities involving problem scenarios. PBL is informed in sessions within which there are small collaborative groups comprised of 6 or 8 students with guidance from a tutor. They deal with scenarios involving several problems that are authentic, complex, ill-structured problems to help students make connections between theory and real-world application. Instruction took 18 class hours in total. The data were analyzed using ANCOVA (Analysis of Covariance). The findings of the study revealed that PBL is more effective than the traditional teaching methods in improving students' conceptual understanding about magnetism topics.

Keywords: Conceptual understanding, Magnetism, Problem based learning

Introduction

During the past few years, physics education research has primarily focused on students' understanding of conceptual physics and the misconceptions that hinder the learning process (Campbell, 2008). The traditional approach to concept teaching consists of the following steps; giving the student the word that expresses the concept, specifying the definition of the concept and identifying and distinguishing qualities needed to understand the definition, to ensure that students find examples related and unrelated to the concepts. This traditional approach is not effective enough in the learning of concepts (Çepni et al., 1997). This is because it is not enough that a student can only identify and memorize the concepts in order to understand concepts and the relationship between these concepts. Instead of this,

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proper learning environments should be created for students where they can study and invent their scientific knowledge as scientists. Thus the student, without the need to memorize knowledge, will gain the ability to conceptualize learning. One of the approaches targeting learning through own experience and discovering knowledge is Problem Based Learning -PBL- (Taşkesenligil, Şenocak & Sözbilir, 2008).

Problem based learning, as an instructional model is receiving increased attention from educational practitioners. The model has developed rapidly in medical school programs since 1980. It is characterized by students' working in small groups to increase knowledge and develop understanding by identifying learning objectives, engaging in self-directed work, and participating in discussions (Barrows & Tamblyn, 1980). It has become a popular mode of delivery in medicine, nursing, and engineering, but far less so in physics. Only in the last decade or so has the teaching of physics through PBL begun to take root (Raine & Collett, 2003). PBL is informed in sessions within which there are small collaborative groups comprised of 6 or 8 students with guidance from a tutor .They deal with scenarios involving several problems (Akınoğlu & Tandoğan, 2007) that are authentic, complex, ill-structured problems to help students make connections between theory and real-world application, as well as develop their ability to handle the complexity of real world (Hung, 2013).

Problem based learning encourages students to think and solve problems in a limited amount of time (Cotton, 2011) and provides authentic experiences that foster active learning, support knowledge construction, and naturally integrate school learning and real life (Torp & Sage, 2002). Aim of PBL is to apply critical thinking, problem solving skills, and content knowledge to real-world problems and issues (Levin, 2001) and to develop self-directed, reflective, lifelong learners who can integrate knowledge, think critically, and work collaboratively with others (Barrows, 1996). The advantage of PBL is that students become more aware of how they can put the knowledge that they are acquiring to use (Hallinger & Lu, 2011). Moreover, there is some evidence of the effectiveness of PBL on increasing students' achievement (Aydoğdu, 2012; Bayrak, 2007; Çelik, Eroğlu & Selvi, 2012; Demirel & Arslan Turan, 2010; Deveci, 2002; Gürlen, 2011; Karadeniz Bayrak & Bayram, 2012; Kartal Taşoğlu, 2009; Mackinnon,1999; Polanco, Patrica & Francisco, 2004; Sezgin Selçuk, 2010; Sezgin Selçuk, Karabey & Çalışkan, 2011; Stattenfield & Evans, 1996; Tarhan et al., 2008; Tavukcu, 2006; Yüceliş Alper, 2003). PBL approach improve also conceptual understanding (Bude et al., 2011; Sahin 2010a), and develop critical thinking (Cantürk Günhan & Baser, 2009; Ozturk, Muslu & Dicle, 2008).

In addition, PBL generate students' interest and motivation (Demirel & Arslan Turan, 2010; Ersoy & Baser, 2010; Inel & Balım, 2011; Tosun & Taşkesenligil, 2012) and improve scientific process skills (Bayrak,2007; Gürses et al., 2007; Kaptan & Korkmaz, 2001; Oskay, 2007; Tatar & Oktay, 2011; Tavukcu, 2006; Tosun & Taşkesenligil, 2013).

There are several studies which have focused on the effectiveness of PBL in different subjects. But research investigating the effectiveness of PBL on conceptual understanding in teaching of magnetism topics is very limited. Evidence suggests that magnetism concepts are poorly understood across a broad range of potential learners (Atwood, Christopher & McNall, 2007; Finley, 1986; Hickey & Schibeci, 1999; Maloney et al., 2001; Tanel & Erol, 2008). A few studies on physics education were given below.

PBL applied to the General Physics II (Eren & Akınoğlu, 2012) and to the Newtonian Mechanics (Sahin, 2010b) showed that PBL group gain higher conceptual learning than the traditional group. A similar result (Akınoğlu & Tandoğan, 2007) showed that PBL approach had positively affected students' academic achievement and their attitudes towards the science course, as well as students' conceptual development and misconceptions. Because only a few reports of PBL application in teaching of magnetism topics have appeared to date, the aim of this study is to examine effect of PBL on conceptual understanding in teaching of magnetism topics.

Methodology

In this research, a quasi-experimental, nonequivalent control group design was implemented to investigate the effects of PBL on conceptual understanding in teaching of magnetism topics.

Sample

The research was conducted with 48 students attending of 1st class of the Department of Science Education in a state university in Turkey.

When the students were assigned to the experimental and the control groups, first of all they had been ranked from the highest grade to the lowest grade by considering their passing grades from the Physics I lesson. The ones who rank in the odd numbers had been assigned to the control group and the ones who rank in even numbers had been assigned to the experimental group.

Concept Test of Magnetism Topics

A concept test of magnetism topics was developed to identify students' conceptual understanding about units of "Magnetic Field and Its Effects", "Magnetic Field Sources" and "Magnetic Flux and Induction Law". In the preparation procedure of the test, firstly the common misconceptions encountered in the literature on the subject (Barrow, 2000; Demirci & Çirkinoğlu, 2004; Guisasola, Almudi & Zubimendi, 2004; Kocakülah, 1999; Maloney et al., 2001; Raduta, 2005) and concepts with learning difficulties (Albe, Venturini & Lascours, 2001; Guisasola, Almudi & Zubimendi, 2004; Guisasola et al., 2009; Herrman, 1991; Jones, 2003; Kocakülah, 1999; Maloney et al., 2001; Manogue et al., 2006; Raduta, 2005; Sağlam & Millar, 2006; Tanel & Erol, 2005a; Tanel & Erol, 2005b) were reviewed.

When preparing the concept test questions, some misconceptions and some of the concepts with learning difficulties were selected. To determine these concepts with learning difficulties, 26 open-ended questions were prepared. Four faculty members were interviewed about the questionnaire in order to ensure the validity of the test. The test was also administered to Physics and Mathematics Education students (N=64). After considering the experts' opinions and students' answers, questions were re-arranged and then, three questions were removed from the test. The final test consists of 23 questions and three questions (8.,10. and 21.) are divided into a and b options. Sample questions of the test had been given in the Appendix A.

Concept test questions are classified into four categories as "sound understanding", "partial understanding", "incorrect understanding", "no understanding/no response". These categories are also used by many researchers (Abraham et al., 1992; Ayas, Özmen & Çalık, 2010; Cındıl, Özmen & Ünal, 2012; Özmen, 2003).

The categories used during the analysis of the students' responses and their definitions are as below:

Sound Understanding: Responses that contained the whole or a big part of the scientific ideas that constituted the response of the question had been evaluated in this category.

Partial Understanding: Responses that contained some part of the scientific ideas that constituted the response of the question had been collected in this group. There are not expressions that contradicted with the scientific ideas, misconceptions on the responses of the students in this category.

Incorrect Understanding: Responses that contradicted with scientific ideas, unrelated or wrong responses had been collected in this category.

No Understanding/No Response: Students who had completely left the question empty and responses such as “I did not understand”, “I have no idea” had been evaluated in this category.

Sound understanding responses were scored with 3 points, partial understanding responses were scored with 2 point, incorrect understanding responses were scored with 1 point, and no understanding/no response answers were scored with zero point. The maximum score and minimum score of the test are 78 and zero, respectively.

To provide validity of the analysis, interviews were conducted with ten students equally selected from the control and the experimental groups.

Treatment in the Experimental Group

After the units’ learning gains and teaching duration were identified, scenarios with five stages were prepared in accordance with the learning gains of the units (a sample scenario is presented in Appendix B).

Before PBL implementation, pilot application of these scenarios was applied in order to determine whether or not students reached the learning gains, and finally required corrections to the scenarios were made by the researcher.

Before starting the PBL application, the experimental group was divided into 3 groups according to their achievement in the Physics I course in the autumn semester. Heterogeneous groups were organized according to students’ achievements.

First of all, a presentation was made to inform the experimental group students about what PBL is, and how PBL lessons proceed. Later, tutor presented problem scenarios to group members. PBL activities involved problem scenarios developed through the following steps:

1. Students were introduced to the problem situation.
2. Each group members delivered their ideas about the problem and expressed their opinions through discussion.
3. Group members shared their prior knowledge of the problem.
4. Group members defined and discussed the information necessary to solve the problem.
5. If all group members didn’t have information on the subject, they would research it after the session.
6. Discussing with group members and the tutor, solutions to the problem of the groups were presented by group members in the same or another session.
7. The application took seven sessions including five stages and this took 14 class hours. In addition, 4 class hours were used for the pre-test and post-test applications.

Treatment in the Control Group

The control group was taught using traditional teaching methods which are based on teachers’ explanations and question-answer methods. Students were passive participants during the lessons.

Data Analysis

The data were analyzed using ANCOVA (Analysis of Covariance). Although there was not a significant difference in concept pre-test results of the students in both experimental and control group students before the implementation, ANCOVA was used to eliminate the existing difference between groups. A p-value of less than 0.05 was considered to be statistically significant.

Effect size was measured via partial eta-squared, in which small, medium, and large effects were operationalized as 0.01, 0.06 and 0.14, respectively (Stevens, 1992).

Results and Discussion

Descriptive statistics related to total mean scores of pre-test and post-test and corrected means for post-test after ANCOVA are presented in Table 1.According to Table 1, post-test total mean scores are higher than pre-test total mean scores. In addition, the experimental group post-test total mean scores ($\overline{X}$ =38.42, SD=9.83) are higher than the control group ($\overline{X}$ =29.79, SD=12.14).

Table 1. The average values for the test of groups

Groups	N	Pre-test		Pos-test		Corrected Means of post test after ANCOVA
		Mean	SD	Mean	SD	
Experimental	24	16.50	6.90	38.42	9.83	37.53
Control	24	13.08	8.20	29.79	12.14	30.67

ANCOVA results (Table 2) also confirms that there is a statistically significant difference between the corrected total mean scores of students in the experimental group ($\overline{X}$ =37.53) compared to the control group ($\overline{X}$ =30.67) students (F(1-45)=4.94; p=0.031; partial η^2 =0.098). According to the Steven’s criteria, the effect size is above the medium.

Table 2. ANCOVA results of the concept test scores

Source	Sum of squares	df	Mean square	F	p	partial η^2
Pre-test	705.67	1	705.67	6.47	0.014	0.126
Group	536.40	1	536.40	4.92	0.031	0.098
Error	4904.12	45	108.98			
Total	6502.48	47				

The above findings offer evidence that PBL could be more effective on conceptual understanding in teaching of magnetism topics than the traditional teaching methods. This result is in parallel with the results of research which was based on the PBL (Akınoğlu & Tandogan, 2007; Bude, Wiel, Imbos & Berger, 2011; Eren & Akınoğlu, 2012; Sahin, 2010a; Sahin 2010b). Besides, the results obtained from the post-test are presented below by taking each question for experimental group and control group.

As can be seen from Table 3, “sound understanding” and “partial understanding” percentages of experimental group is generally more than the control groups. In addition, it is found that points of the analysis (as mentioned chapter 2.2.) agree great extent (%98.5) with students’ answers obtained from interviews.

Table 3. Percentages of responses given to each question

Question	Experimental group responses				Control group responses			
	SU(%)	PU(%)	IU(%)	NU/NR(%)	SU(%)	PU(%)	IU(%)	NU/NR(%)
1	20.8	12.5	37.5	29.2	16.7	8.3	29.2	45.8
2	8.3	-	70.8	20.8	4.2	12.5	54.2	29.2
3	45.8	41.7	12.5	-	16.7	41.7	25	16.7
4	-	25	58.3	16.7	4.2	8.3	33.3	54.2
5	33.3	8.3	4.2	54.2	20.8	8.3	29.2	41.7
6	95.8	-	-	4.2	70.8	16.7	8.3	4.2
7	4.2	-	79.2	16.7	4.2	4.2	75	16.7
8a	16.7	25	54.2	4.2	16.7	16.7	58.3	8.3
8b	20.8	50	20.8	8.3	12.5	50	29.2	8.3
9	12.5	-	79.2	8.3	12.5	4.2	58.3	25
10a	54.2	-	33.3	12.5	29.2	-	62.5	8.3
10b	41.7	-	45.8	12.5	16.7	-	62.5	20.8
11	29.2	29.2	25	16.7	16.7	8.3	58.3	16.7
12	27.1	6.3	54.2	12.5	25	4.2	58.3	12.5
13	16.7	12.5	50	20.8	20.8	4.2	37.5	37.5
14	14.6	18.8	58.3	8.3	14.6	2.1	79.2	4.2
15	-	-	95.8	4.2	-	-	70.8	29.2
16	50	20.8	-	29.2	12.5	8.3	12.5	66.7
17	20.8	20.8	54.2	4.2	-	20.8	50	29.2
18	16.7	20.8	50	12.5	4.2	16.7	45.8	33.3
19	20.8	16.7	33.3	29.2	8.3	20.8	20.8	50
20	4.2	8.3	58.3	29.2	-	25	41.2	33.3
21a	45.8	8.3	29.2	16.7	33.3	-	37.5	29.2
21b	16.7	6.2	52.1	25	16.7	4.2	50	29.2
22	4.2	8.3	41.7	45.8	16.7	4.2	37.5	41.7
23	45.8	4.2	45.8	4.2	20.8	-	25	54.2

SU: Sound Understanding, **IU**: Incorrect Understanding, **PU**: Partial Understanding, **NU/NR**: No Understanding/ No Response

Conclusion and Suggestion

When the scores of the experimental and control groups from the concept test regarding the magnetism topics were examined, it was detected that the conceptual understandings of both groups regarding the magnetism topics were increased. As when the post test scores of the experimental and the control groups were compared, it was found that the conceptual understanding of the experimental group regarding the magnetism topics was increased more than the control group. While the responses given to the test were evaluated, the students of the experimental group were observed to respond by giving more explanations. This result can also be seen on the findings (Table 3), when the findings were examined, the percentages of responses given in the "sound understanding" and "partial understanding" categories were observed to be usually higher in the experimental group in contrast with the control group. In addition, when the responses given to the test were examined, the students of the control group were observed to leave the questions empty more frequently. As a result of this, when the percentages of responses given in the "no understanding/ no response" category were examined, it was found that the percentage rates were much higher in the control group in contrast with the experimental group. Besides, according to effect size, it has been appeared that difference obtained from instructional methods had carried practical significance.

The findings of the study revealed that PBL approach is more effective than the traditional teaching methods in improving students' conceptual understanding about magnetism topics. This approach makes the concepts of magnetism which are abstract according to students more concrete because the scenarios used in this approach occur in daily life events. This enables the development of the conceptual understanding of the students. Moreover, this result may have been obtained due to PBL's cognitive effects (Schmidt, 1993) on students learning. Students' cognitive levels play an important role in mental construction. When learning environments are designed to enhance the learners' thinking and problem solving skills, instead of simply memorizing knowledge, students mentally internalize it with meaning and it will be permanent (Demirel, 2011). These learning environments are already available in the PBL approach.

Besides, according to Duch, Groh, and Allen (2001), problem scenarios are related to the daily life of the students and address their sense of wonder, thus playing a role in triggering their learning. Complex and real-life problems are used to establish the principles and concepts necessary for the students to learn and also to motivate them to research. By doing this study with prospective teachers, we believe that they will more prone to using PBL approach and other similar methods in their professional lives. This is another important contribution to education.

The hardest process of PBL approach is to prepare scenarios suitable to the learning gains of the subject. Therefore books that explain how to prepare the scenarios and that contain sample scenarios should be prepared. In addition to this, as tutor in the process of implementing the PBL approach is interested with each group, not having too much group number and too much student number in the group should be paid attention. It is expressed as another suggestion that the PBL approach should be used to make learning more effective in other subjects that are difficult to understand in physics or other fields. PBL issues may become more colorful with field trips related to the subjects and in this case, learning can be more effective and lasting.

In addition, if experiments that might be created by using simple tools regarding the topics in the preparation phase of the problem-based learning are designed and if the questions in the scenario are argued during this experiment, students might understand the subject better and the knowledge they had learned might be more permanent. In a session of this study, the students had established an electrical motor mechanism (Figure 1) in groups and they had worked this mechanism.

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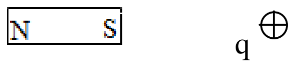
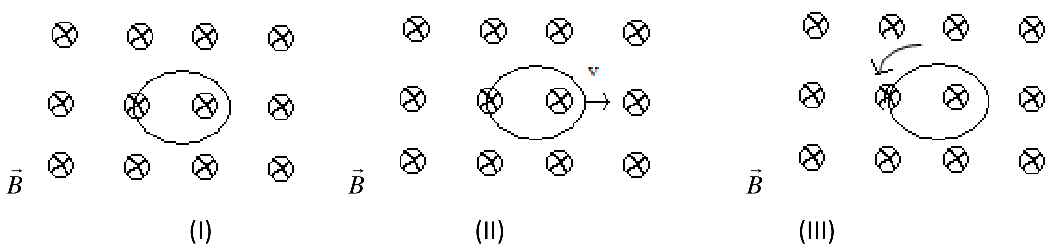
APPENDIX A

Sample Questions of the Concept Test

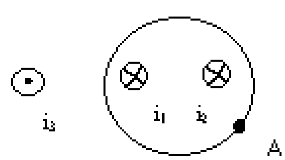
1) Does the magnetic force affect a positive point charge which is left close to the S pole of a magnet? If it moves, draw its orbital track. Explain your response.



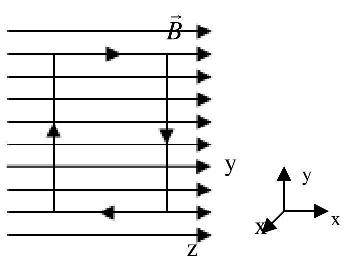
2) The circular conducting wire is placed to the straight $\vec{B}$ magnetic field vertically inwards of the sheet plane. The circular wire is still in case I, it moves towards right with the constant speed without getting out of the magnetic field in case II, and it turns counterclockwise around a parallel axis of the magnetic field in case III. Does an induction current form on the circular wire in cases I, II and III? Explain.



3) A current is carried from three conducting wires, as inwards from the sheet plane from the 1st and the 2nd, and outwards from the sheet plane from the 3rd. The magnetic field strength on the A point that takes place on the closed path at L length that covers the 1st and the 2nd wire depends on which of the followings according to the Ampere's law? i_1, i_2, i_3, L, μ_0, the distance of the 1st wire to the A point, the distance of the 2nd wire to the A point, the distance of the 3rd wire to the A point



4) A rectangular loop is placed to the straight $\vec{B}$ magnetic field in the + x axis direction as its plane parallel to the magnetic field and a current passes from the loop clockwise. Explain how will the loop move by finding the direction of magnetic force that acts each side of the loop?



APPENDIX B

A Sample Scenario Used in This Study

"Physics teacher gave a project homework to Alper. The subject of the homework is preparation of a simple electric motor circuit. For this purpose Alper decided the materials he was going to buy, by researching the sources about electricity motor. The next day he purchased the materials he determined which are a battery of 1.5V, coil wire of 1m length, ring wire of 0.5m, 2 hasps and Styrofoam. He hold the coil wire with two hands and winded it thickly so that it would not bend with its own weight. He revved the ends of the coil wire through the holes of the hasps supported on the Styrofoam and kept it on balance. He connected the ends of the wire to the poles of the battery. When he adducted the magnet close to the coil wire, the wire started winding."

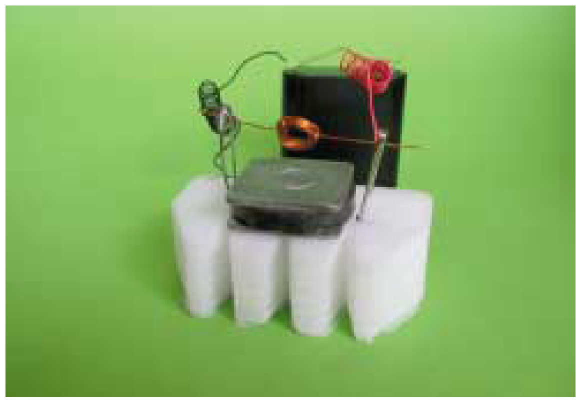


Figure 1. A simple electric motor circuit

1. Scientifically explain the winding of the wire by adducting the magnet to the conductive wire.
2. If we take away the magnet from the circuit in the assembly in the figure and place a compass instead, will the direction of the compass change?
3. How will the movement of the positively charged particle which enters perpendicularly to the magnetic field that is directed inwards the page plane be? Explain by drawing.