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Effects of Problem-Based Learning on Student Attitudes, Achievement and Retention of Learning in Math Course *

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Abstract

This study investigates the effects of problem-based learning (PBL) on student attitudes, achievement and retention of learning in 5th grade math course. It is a quasi-experimental study that uses pre-test-post-test design with a control group. It was conducted on a total of 60 fifth-graders attending an elementary school in Çankaya, Ankara in two groups. Data were collected by using the "Math Attitude Scale" and the "Math Achievement Test". The experiment took 6 weeks. Instruction was offered with PBL materials in the experimental group and with regular materials as designed by the class teacher in the control group. At the end of the study, no statistically significant difference was found between the mean attitude scores of experimental and control students towards the math course. On the other hand, significant differences in favor of the experimental group were found in the achievement and retention levels of the two groups.

Keywords

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Introduction

Recent reforms in math education have brought new demands with them. Among these are offering students meaningful activities and giving them an opportunity to discuss and share their information in a social environment in the instructional process (National Council of Teachers of Mathematics [NCTM], 2000). Different learning methods based on such activities are used particularly in elementary schools. One of these methods is "Problem-Based Learning" (PBL), which is an experience-based method of learning organized to research and solve complex real-life problems (Sage and Torp, 2002, p.15).

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Latest studies on PBL mostly emphasize that it is a method that enables students to actively fulfil the role of learner (Abacıoğlu et al., 2002; Barrows, 1986; Nardone and Lee, 2011; Yıldızlar, 2001). Most studies on PBL have centered around the teaching of different fields on tertiary level. Most of these studies have been in the fields of medicine, engineering, and science and math education (Akpınar and Ergin, 2005; Blake, Hosokawa and Riley, 2000; Boyacıoğlu, Selçuk and Şalk, 2005;Burgaz and Erdem, 2006;Gülsüm and Sungur, 2007; Kaptan and Korkmaz, 2002; Liu, 2003; Özdemir, 2005; Özel, Timur, Özyalın and Danışman, 2005; Sylvie, Andre and Jaques, 2001; Şendağ, 2008; Yaman, 2003).

There are studies on elementary and secondary level, too. These studies have mostly been in Science, Math and Social Studies courses. On the whole ,PBL was found to contribute to increase and maintain academic success (Akınoğlu and Tandoğan, 2007; Çiftçi et al., 2007; Demirel and Turan, 2010; Deveci, 2003; Gülsüm and Sungur, 2007, Günhan, 2006; Gürsul, 2008; Sifoğlu, 2007; Tandoğan, 2006;Tavukçu, 2006; Uslu, 2006; Yurd, 2007), improve performance skills (Gülsüm and Sungur, 2007), have positive effects on attitudes towards classes (Akınoğlu and Tandoğan, 2007; Çiftçi et al., 2007; Günhan, 2006; Gürsul, 2008; Korucu, 2007; Tandoğan, 2006; Tavukçu, 2006; Uslu, 2006; Yurd, 2007), enhance communication and self-learning skills (Diggs, 1997), as well as motivation and independent working skills (Cerezo, 2004), and produce more logical solutions to problems faced (Elshafei, 1999). Other studies have shown that PBL made secondary students enjoy group work and show them how it is used in real life (Katwibun, 2004), improved geometric thought in math class, positively affected self-competence beliefs in geometry, and enhanced critical thinking skills (Günhan, 2006).

Kaptan and Korkmaz (2001: 186) state that PBL is key for students to transfer the knowledge and skills they learn in math class to real life, and to cope with daily problems. It is also evident from the success of countries that rank high on international exams such as the International Association for the Evaluation of Educational (IEA) TIMSS project and the Programme for International Student Assessment (PISA) that problem solving is crucial for math education (Anderson, 2009; Kaur, 2001; Kaur and Yeap, 2009; Pang, 2004).

Theoretically, PBL is based on constructivism (Turan and Demirel, 2011) and its approach to instructional design is based on problem solution and "contextual learning" (Şimşek, 2011).At the same time, it is based on John Dewey's "discovery learning"(Rhem, 1998; Cited in Çalışkan et al., 2011; Balım et al., 2007) and is in accord with the main philosophy and overall goals of the math curricula for grades 1 through 5 (MEB, 2005). The present study was designed based on previous research and existing opinions in order to reveal whether learner centered practices improve student achievement and attitudes in math courses, try it out and show its results in math courses in the first stage of elementary education in Turkey, and set an example for learner centered studies.

Taking into consideration cognitive development levels, the study also aimed to meet the math course objectives through PBL and thus make students learn better and enjoy the course more during the transition from concrete operations to abstract operations stage in the 5th grade. Another aim was to explore whether the advantages of this method would lead to a positive effect in making students obtain the abstract concepts included in the math curriculum and their attitudes towards the course.

The primary problem of this study was to seek an answer to the following question: "Is there a significant difference between the attitude, achievement test and retention test mean scores of fifth graders who studied math through Problem-Based Learning in the experimental group and those who studied it in the way designed by the teacher in the control group?"

Sub Problems

1. Is there a statistically significant difference in the fifth-grade math course between the:

a) pre- and post-test mean scores obtained by PBL (experimental) students from the "Math Attitude Scale"?

b) pre- and post-test mean scores obtained by regular (control) students from the "Math Attitude Scale"?

c) post-test mean scores obtained by experimental and control students from the "Math Attitude Scale"?

2. Is there a statistically significant difference in the fifth-grade math course between the:

a) pre- and post-test mean scores obtained by experimental students from the "Math Achievement Test"?

b) pre- and post-test mean scores obtained by control students from the "Math Achievement Test"?

c) post-test mean scores obtained by experimental and control students from the "Math Achievement Test"?

3. Is there a statistically significant difference in the fifth-grade math course between the:

a) mean scores obtained by experimental students from the "Math Achievement" post-test and retention test?

b) mean scores obtained by control students from the "Math Achievement" post-test and retention test?

c) mean scores obtained by experimental and control students from the "Math Achievement" retention test?

Method

Research Model

The study used pretest-posttest control group quasi-experimental research design to examine the effects of using PBL in 5th grade math course on students' attitudes towards the course, academic achievement and retention levels. Instruction in the experimental group was based on PBL. Control group did not receive any intervention and followed the regular instruction outlined in the teacher guide of the Ministry of Education.

Study Group

The study group comprised a total of 60 students who were attending Grades 5-B and 5-C in an elementary school in Çankaya, Ankara during the second semester of 2009–2010 school year. The study was conducted on two classes which were shown to be equivalent with an examination of reports grades, pre-attitude mean scores and pretest achievement means in four different fifth-grade classrooms. With random assignment, 5/C was assigned as the experimental group and 5/B as the control group.

Statistical data on the report grades, pre-attitude mean scores and pretest achievement mean scores of the study group are given in Tables 1, 2 and 3.

Table 1. Experimental and Control Groups' Math Course Report Grades

Group	Number of participants N	Arithmetic Mean $\bar{X}$	Standard Deviation SS	Freedom Level d	(t)	Significance Level (p)
Experimental	30	4,3667	0,99943	58	-0,721	0,474
Control	30	4,5333	0,77608			

*p> 0.05

As can be seen from Table 1, there was no significant difference between the math course report grades of the two groups before the experiment, thus showing equivalence between them. However, the report grades ranged between 1-5. As these values are small, so is their variance. In such cases, for fear that the significance of the difference would not be obvious, achievement and attitude pretest scores were also reviewed.

Table 2. Experimental and Control Groups' Math Course Achievement Pretest Scores

Group	N	$\bar{X}$	SS	Sd	t	p
Experimental	30	12,37	2,773	58	-0,172	0,864
Control	30	12,4667	1,54771			

*p> 0.05

Table 2. shows that experimental and control groups were equivalent at the beginning of the experiment regarding "Math Achievement Test".

Table 3. Experimental and Control Groups' Math Course Attitude Pretest Scores

Group	N	$\bar{X}$	SS	Sd	t	p
Experimental	30	73,67	9,697	58	-0,037	0,970
Control	30	73,77	11,069			

*p> 0.05

As shown in Table 3, experimental and control groups were equivalent prior to the experiment regarding their attitudes.

Data Collection Instruments

The first sub problem of the study was investigated by using the "Math Attitude Scale" that measures students' attitudes towards math class, whereas the second and third sub problems were investigated by using the "Math Achievement Test" that covers the objectives of the "Circumference and Area" sub learning domain of the "Measurements" topic in Grade 5 Math curriculum.

Math Attitude Scale: The scale was designed by Aladağ (2005) as a five-point Likert scale. The statements used in the scale were written by the researcher by referring to the attitude scales previously developed by Fennema and Sherman (1978), Baykul (1990), and Sulak (2002). Initially it had 24 items. The Likert type statements were piloted on A group of 200 individuals. The Cronbach Alpha reliability of the scale was 0,82. Its validity was tested via factor analysis, found a single factor structure was found. Items with a factor load value of 30 or more were included in the scale, while those with a lower value were excluded. As a result, 18 items were selected to be used in the study and construct validity of the scale was ensured. The latest version of the scale was given to a total of 15 field experts and academics (1 Prof., 2 Assoc. Prof., 12 Assist. Prof.), and revisions were made in line with their comments. This ensured content validity of the scale.

The instrument contains a total of 18 attitude statements, 9 positive and 9 negative. The likert type alternatives and their scores were: "*completely agree* (5)", "*agree* (4)", "*undecided* (3)", "*disagree* (2)", "*completely disagree* (1)". For statistical analyses, positive statements were scored as follows starting from "*Completely Agree*"5,4,3,2,1; while negative statements were scored as follows starting from "*Completely Agree*" 1,2,3,4,5. The lowest score possible from the scale is 18, and the highest 90 points. The scores were interpreted as follows: 1- 18 = 1; 19- 36 = 2;37- 54 = 3; 55-72 = 4; 73-90 = 5; between 1 - 2 (negative); 3 (Neutral); 4-5 (positive). The Cronbach Alpha reliability coefficient in this study was found to be 87.

Math Achievement Test: **T**he instrument was developed by examining the measurements objectives listed in the Ministry of Education's (MoE) (2009) 5th grade math teacher guide book and selecting those that appeared for the first time in Grade 5. A total of 7 objectives regarding these learning fields were found. To ensure content validity, the 25 four-alternative multiple choice questions of the Math Achievement Test included at least two questions for each objective, depending on their weight and time in the guidebook. After making necessary revisions, the reliability of the test and its level of discrimination was investigated by giving the test to 142 students at an elementary school. Item analysis on this data was conducted by using the "ITEMAN" program. The results showed difficulty indices between 0.31 and 0.84, discrimination indices between 0.30 and 0.81. A typically good item was defined as one with a difficulty index between 0.30 – 0.90 and discrimination index above 0.20 (Büyüköztürk et al., 2008). No item was removed from the test and the final version included 25 items. Later, the reliability coefficient of the test was found to be 0,78. These results showed the test as one that serves its purpose and it was therefore used in the study as the "Math Achievement Test".

Stages of the Experiment

1. The equivalence of students attending four different Grade 5 classes in a school located in Çankaya, Ankara was established by looking at their first semester math report mean scores and the dependent variables of math achievement and attitude. The findings showed two classes to be equivalent and these were randomly assigned as 5-C experimental and 6-B control.

2. Prior to the experiment, both groups received the "Math Achievement Test" and "Math Attitude Scale" as pretest.

3. In the experimental group, Problem-Based Learning was used for instruction. Fifteen different scenarios were prepared in relation to the "Measurements Sub Learning Domain" .

4. These scenarios were used for six weeks, 4 hours weekly (for a total of 24 class hours).

5. As the scenarios were used, students worked in the classroom, in the library and the computer lab in each session. The teacher brought necessary learning materials to class and shared them with the students.

6. As worksheets were used, the operational stages mentioned by Kaptan and Korkmaz (2001) and Meyer (2003) were considered.

7. At the end of the experiment, the "Math Achievement Test" and "Math Attitude Scale" were implemented as posttest.

8. Three weeks after the completion of the experiment, retention of student achievement was tested by implementing the "Math Achievement Test" as a retention test.

Materials and Duration of Implementation in Problem-Based Learning

In developing Problem-Based Learning materials, the objectives of the 5th grade math course "Measurements" learning domain and "Circumference and Area sub learning" domain were identified, which was followed by the preparation of objective-related lesson plans and PBL course materials by the researchers. The problem cases were offered to the students by making use of stories, pictures, advertisements, and 15 worksheets developed by the researcher covering all objectives. While PBL Materials and lesson plans were being prepared, the views of field experts (1 professor, 1 assoc. prof., 1 assist. prof.) and class teachers were taken, and final revisions were made. Of the sample lesson plans, two were implemented in a different class other than the study groups for a trial. The plans were evaluated for feasibility, student interest and timing.

When worksheets were implemented, Kaptan and Korkmaz's (2001) and Meyer's (2003) stages were followed. These were as follows:

- The experimental group was divided into five groups of six individuals each.
- The seating arrangement in the classroom was organized to accommodate group work.
- The groups were introduced to the method, icebreakers were used and a trial was made.
- Materials including the problem case were distributed to students so that everyone knew the problem.
- Students worked in groups and defined the problem by using previous knowledge.
- They developed solutions.
- Each group was to discuss the different solutions they came up with and agree on one.
- After all groups finished, they prepared an oral and written presentation of their definition of the problem, their solutions and reasons.
- At the end of the experiment, the most successful group was awarded with an achievement certificate prepared by the researcher.

As the experimental group followed the practices outlined above, the control group followed the regular course syllabus recommended in the teacher's guidebook.

Data Analysis

The presence of a significant difference between the groups' pretest, posttest and retention scores (math attitude and achievement) was tested by using t test for independent groups. Data were analyzed on package programme. As the findings were interpreted, the experiment conditions, previous practices and the small number of measurements in the groups were considered.

Findings

For the first subproblem, answers to the three following items were sought.

1. a) Is there a statistically significant difference in the fifth-grade math course between the pre- and post-test mean scores obtained by PBL (experimental) students from the "Math Attitude Scale"? To answer this question, the "Math Attitude Scale" pre and posttest mean scores and standard deviation values of the experimental group were calculated, and t test was used to test the significance of the difference between their pre and posttest scores. Table 4 presents the group's attitude pre and posttest mean scores, standard deviation and t values.

Table 4. Findings on the Pre and Posttest Mean Scores of the Experimental Group in Math Attitude Scale

Measurement	N	$\bar{X}$	SS	Sd	t	p
Pretest	30	73,67	9,697	29	-1,303	0,203*
Posttest	30	76,87	12,632			

* p> 0.05

As shown in Table 4, the arithmetic mean of experimental students' pretest scores was $\bar{X}$=73,67; and their posttest scores $\bar{X}$=76,87. T test was performed to see if the difference between the mean scores was significant and the result was t (29) = -1,303, p> 0.05. This finding suggested that there was no significant difference between the experimental group's pretest-posttest attitude score means.

1. b) Is there a statistically significant difference in the fifth-grade math course between the pre- and post-test mean scores obtained by regular (control) students from the "Math Attitude Scale"?In order to examine this question, the "Math Attitude Scale" pre and posttest mean scores and standard deviation values of the control group were calculated, and t test was used to test the significance of the difference between their pre and posttest scores. Table 5 shows their attitude pre and posttest mean scores, standard deviation and t values.

Table 5. Findings on the Pre and Posttest Mean Scores of the Control Group in Math Attitude Scale

Measurement	N	$\bar{X}$	SS	Sd	t	p
Pretest	30	73,77	11,069	29	-0,096	0,924*
Posttest	30	74,07	12,616			

* p> 0.05

Table 5 shows that the arithmetic mean of control students' pretest scores was $\bar{X}$=73,77; and their posttest scores $\bar{X}$=74,07. T test was performed to see if the difference between the mean scores was significant and the result was t (29) = -0,096, p> 0.05. Accordingly, no significant difference exists between the pretest-posttest attitude score means of the control group.

1. c) Is there a significant difference between the post-test mean scores obtained by experimental and control students from the "Math Attitude Scale"? The answer was decided by examining the post the mean scores and standard deviations of the experimental and control groups on the "Math Attitude Scale", and by using t test in order to see the significance of the difference. The posttest mean scores, standard deviation sand t values are presented in Table 6.

Table 6. Findings on the Posttest Mean Scores of the Experimental and Control Groups in Math Attitude Scale

Group	N	$\bar{X}$	SS	Sd	t	p
Experimental	30	76,8667	12,63202	58	0,859	0,394*
Control	30	74,0667	12,61617			

* p> 0.05

As shown in the table, the posttest performed to identify the math attitudes of the experimental and control groups yielded the following arithmetic means: $\bar{X}$=76,8667 for the experimental group and $\bar{X}$=74,0667 for the control group. T test was used to examine whether the difference between the two groups was significant and t (58) = 0,859 was found. A "p" value (0,394) greater than the significance level of 0,05 shows that a significant difference did not exist between the attitudes of the two groups. It may therefore be said that there is no statistical significance between the experimental and control students' attitude posttest results.

The second subproblem focused on three different questions regarding whether there was a significant difference between the math achievement test scores of fifth graders who followed Problem-Based Learning in the experimental group and those who followed the regular instruction in the control group.

2. a) Is there a statistically significant difference in the fifth-grade math course between the pre- and post-test mean scores obtained by experimental students from the "Math Achievement Test"? In order to answer this question, the means and standard deviation values of experimental group pretest and posttest scores from the "Math Achievement Test" were calculated, and t test was used to test the significance of the difference between the pre and posttest scores. The pre and posttest mean scores, standard deviation and t values are shown in Table 7.

Table 7. Findings on the Pretest and Posttest Mean Scores of the Experimental Group in the Math Achievement Test

Measurement	N	$\bar{X}$	SS	Sd	t	p
Pretest	30	12,37	2,773	29	-14,689	0,000*
Posttest	30	22,30	2,292			

* $p < 0.05$

As shown in the table, experimental students' pretest arithmetic mean score was $\bar{X}$=12,37 and posttest mean score was $\bar{X}$=22,30. At the same time, t (29) = -14,689. The posttest mean score (22,30± 2,292) of the experimental group was significantly higher than their pretest mean score (12,37± 2,773). The "p" value (0,00) was smaller than the significance level of 0,05, showing a statistically significant difference between the experimental group's pretest-posttest achievement mean scores. The difference was in favor of the posttest achievement mean scores of the experimental group. These findings show that using PBL in teaching measurements positively affected students' academic achievement.

2. b) Is there a statistically significant difference in the fifth-grade math course between the pre- and post-test mean scores obtained by control students from the "Math Achievement Test"? This question was answered by looking at the means and standard deviation values of control group pretest and posttest scores from the "Math Achievement Test". T test scores to test the significance of the difference between the pre and posttest scores. The pre and posttest mean scores, standard deviation and t values are shown in Table 8.

Table 8. Findings on the Pretest and Posttest Mean Scores of the Control Group in the Math Achievement Test

Measurement	N	$\bar{X}$	SS	Sd	t	p
Pretest	30	12,47	1,54771	29	-9,185	0,000*
Posttest	30	19,07	3,493			

* $p < 0.05$

Table 8 shows that control students' pretest arithmetic mean score was $\bar{x}$=12,47 and their posttest mean score was $\bar{x}$=19,07. The evaluation of tests showed t (29) = -9,185. The posttest mean score (19,07± 3,493) of the control was significantly higher than their pretest mean score (12,47± 1,54771). The "p" value (0,000) was smaller than the significance level of 0,05, showing a statistically significant difference between the control group's pretest-posttest achievement mean scores. The difference was in favor of the posttest achievement mean scores of the control group, indicating that regular instruction by class teachers in teaching measurements also affected students' academic achievement positively.

Based on the findings obtained from subproblems a and b, it is clear that instruction in both experimental and control groups positively affected the academic achievement of math students. It was also found that both groups had a significant difference between the achievement mean scores within themselves. Therefore, it became important to study whether the difference between the posttest mean scores of the experimental and control groups was significant.

2. c) In order to answer the question "Is there a significant difference between the post-test mean scores obtained by experimental and control students from the "Math Achievement Test?", both groups' posttest mean scores and standard deviations were calculated and t test was used to test the significance of the difference between the posttest score means. The posttest mean scores, standard deviation and t values are presented in Table 9.

Table 9. Findings on the Posttest Mean Scores of the Experimental and Control Groups from theMath Achievement Test

Group	N	$\bar{X}$	SS	Sd	t	p
Experimental	30	22,30	2,292	58	4,239	0,000*
Control	30	19,07	3,493			

* p< 0.05

As shown in the table, the Math Achievement Test was implemented as posttest in both experimental and control groups to find whether instruction with Problem-Based Learning and regular instruction made a difference in students' math achievement and the arithmetic mean of the experimental group was $\bar{x}$= 22,30; and that in the control group was $\bar{x}$= 19,07. The experimental group mean score (22,30± 2,292) was significantly higher than the control group mean score (19,0667± 3,49318). T test was used to examine whether the difference between the posttest achievement scores was significant, and the result was t (58) = 4,239. A smaller "p" value (0,000) than the significance level of 0,05 shows that the achievement posttest scores of the two groups differed significantly. This indicates that using PBL in the control group to teach measurements was more influential in bringing academic achievement than the regular instruction given in the control group with no intervention.

The third subproblem of the study focused on three different questions regarding whether there was a significant difference between the retention test mean scores of fifth graders who followed Problem-Based Learning in the experimental group and those who followed the regular instruction in the control group.

3. a) "Is there a statistically significant difference in the "Math Achievement Test" posttest and retention test mean scores of experimental group students?"In order to answer this question, the means and standard deviation values obtained by implementing the "Math Achievement Test" in the experimental group as posttest and retention were calculated, and t test was used to test the significance of the difference between the posttest and retention test mean scores. The posttest and retention test mean scores, standard deviation and t values can be seen in Table 10.

Table 10. Findings on the Posttest and Retention Test Mean Scores of the Experimental Group in the Math Achievement Test

Measurement	N	$\bar{X}$	SS	Sd	t	p
Pretest	30	21,8333	2,74281	29	-0,641	0,527*
Posttest	30	22,30	2,292			

* p> 0.05

Table 10 shows that the arithmetic mean of experimental group students' posttest scores was $\bar{x}$=22,30; and that of the retention test scores was $\bar{x}$=21,8333. At the same time, t (29) = -0,641. The presence of a significant difference between the experimental group's retention test mean score (21,8333± 2,74281) and posttest mean score (22,30± 2,292) was studied. A "p" value (0,527) greater than the significance value of 0,05 (p> 0.05) shows that a statistically significant difference existed between the retention and posttest achievement mean scores of the experimental group.

3. b) "Is there a significant difference between the mean scores obtained by control students from the "Math Achievement" post-test and retention test?"The answer to this question was sought by calculating he mean scores and standard deviation values that the control group received from the posttest and retention test implementations of the "Math Achievement Test", and by using t test to see the significance level of the difference between posttest and retention test mean scores. Table 11presents posttest and retention test mean scores, standard deviation and t values.

Table 11. Findings on the Posttest and Retention Test Mean Scores of the Control Group in the Math Achievement Test

Measurement	N	$\bar{X}$	SS	Sd	t	p
Retention	30	18,8667	4,00632	29	-0,232	0,818*
Posttest	30	19,07	3,493			

* p> 0.05

Table 11 presents the arithmetic mean of control children's posttest scores as $\bar{x}$=19,07 and that of retention test as $\bar{x}$=18,8667. Regarding the significance of the difference, t(29) = -0,232. The presence of a significant difference between the control group's retention test mean score (18,8667±4,00632) and their posttest mean score (19,07± 3,493) was studied, and a "p" value (0,818) greater than 0,05 (p> 0.05) showed that no statistically significant difference existed between the retention test and posttest achievement mean scores of the control group.

3. c) "Is there a significant difference between the mean scores obtained by experimental and control students from the "Math Achievement" retention test?"In order to investigate this, a retention test was given to both experimental and control group students 3 weeks after the completion of the study. Retention test mean scores obtained by experimental and control groups in the "Math Achievement Test" and their standard deviations were calculated, and t test was used to test the significance of the difference between the retention test mean scores of the groups. These values are presented in Table 12.

Table 12. Findings on the Retention Test Mean Scores of the Experimental and Control Groupsin the Math Achievement Test

Group	N	$\bar{X}$	SS	Sd	t	p
Experimental	30	21,8333	2,74281	58	3,347	0,001*
Control	30	18,8667	4,00632			

* $p< 0.05$

Table 12 shows the results pertaining to the Math Achievement Test given as retention test to both PBL experimental and regular instruction control groups 3 weeks after the completion of the study. As can be seen, the arithmetic mean of the experimental group was $\bar{x}$= 21,8333 and that of the control group was $\bar{x}$= 18,8667. T test was used to examine whether the difference between the retention test mean scores of the two groups was significant and it was found that t (58) = 3,347. A "p" value (0.001) smaller than 0,05 reveals a significant difference between the two groups' retention test mean scores, similar to the means of the posttest mean scores. the difference was in favor of the experimental group's retention test score. These findings suggest that using PBL had a more positive effect on students' retention levels and permanence of knowledge than regular instruction in the teaching of the measurement learning domain.

Conclusion, Discussion and Recommendations

Conclusions reached by the findings obtained in this study are given below: Regarding the first subprobleme of the study, no statistically significant difference was found between the mean scores obtained from the pre and post implementations of the "Math Attitude Scale" in both experimental and control groups. The same is true for the post implementation of both experimental and control groups. However, attitude scores were high in both groups. The six-week process did not lead to any statistically significant difference in attitudes in either group. Contrary to this finding, PBL was shown to cause an improvement in student attitudes in Akın's (2009) 4-week study on the fractions sublearning domain of 5th grade math course, Özsarı's (2009) study on the natural numbers sublearning domain of 4th grade math course, and other studies by Akın (2009), Bukova (2006), Gürsul (2008), Özgen (2007), Özsarı (2009) conducted in math course at different grade levels. In other courses where PBL was used, a similar positive statistical difference was found in the attitudes of students in experimental groups, too (Akınoğlu and Tandoğan, 2007; Diggs, 1997; Deveci, 2003; Günhan, Gürsel, 2008; 2006; Karagöz, 2008; Korucu, 2007; Özgen, 2007; Özsarı, 2009; Uslu, 2006; Yurd, 2007; Tandoğan, 2006; Tavukçu, 2006;). Even though attitude towards the course was investigated in this study, Liu (2003) studied how the use of PBL changed the views of first-year engineering students on mathematical thought. At the end of the 18-week implementation and instruction, students were found to define mathematical thought better than they did before and their views were found to have become more positive. Based on this and other results, it may be claimed that longer studies are needed to test affective learning and longer implementations are needed to improve student attitudes.

In the second and third subproblems of the study, a statistically significant difference was found between both experimental and control group students' pre and post "Math Achievement Test" mean scores. Instruction improved student achievement in both groups, which is a favorable educational outcome. Günhan's (2006) study of a math class and Tandoğan's (2006) study of a science class corroborate the results of this study. However, a significant difference was found between the posttest mean scores of the experimental and control groups, in favor of the former.

Considering "Math Achievement Test" retention mean scores, a significant difference did not exist between posttest and retention test mean scores in either experimental or control group; however, the comparison between groups showed a significant difference in favor of the experimental group. At the same time, it was found that that this difference stemmed from the difference between students' posttest mean scores, thus suggesting that forgetfulness was similar in both groups. These results are similar to those of Günhan (2006) found in a math class, Tavukçu (2006) in a science education class, and Taşoğlu and Bakaç (2009) in a physics education class. Tarhan et al. (2008) concluded in their study that PBL increased student achievement more than traditional methods of instruction. There are other previous studies which document the positive effects of PBL on both academic achievement and retention (Akın, 2009; Akınoğlu and Tandoğan, 2007; Besana et al., 2004; Cerezo, 2004; Çiftçi et al., 2007; Deveci, 2003; Elshafei, 1999; Gülsüm and Sungur, 2007; Günhan, 2006; Gürsul, 2008; Özgen, 2007; Özsarı, 2009; Sifoğlu, 2007; Tandoğan, 2006; Tavukçu, 2006; Uslu, 2006; Yurd, 2007). In addition, the study of PBL in many branches of science such as medicine, engineering, science, social studies, and math revealed that it improved the academic achievement of students (Blake et al., 2000; Diggs, 1997; Elshafei, 1999; Haris et al., 2001; Katwibun, 2004; Liu, 2003; Mergendoller et al., 2006; Turan and Demirel, 2011).

Other studies about the use of PBL in the "Measurement" learning domain of math and infractions and natural numbers sublearning domains (Akın, 2009; Özsarı, 2009) also showed that it has positive effects on achievement and may be used in the teaching of other learning domains, too. Lesson plans prepared in accord with this method may benefit practising and preservice teachers. Student and teacher views regarding this process may be obtained to identify the advantage and disadvantages faced in the implementation of PBL. The solutions in worksheets may be analyzed to show the effects of PBL on the strategies that students use when solving problems. Based on the observations of the researcher, the information level increase in students in inclusive education with the use of peer teaching in PBL group work may be investigated.

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