IJQE

International Journal of Quality in Education

Online, https://dergipark.org.tr/tr/pub/ijqe

Volume: 8(1), 2024

e-ISSN:2636-8412

DETERMINING THE EFFECT OF PROBLEM-BASED LEARNING ON STUDENTS' ACADEMIC ACHIEVEMENT IN MATHEMATICS LESSONS

Hasan BOZ (Ministry of National Education, Türkiye)

bozhasen@hotmail.com
ORCID: 0000-0002-1538-7290

Prof. Dr. Füsun Gülderen ALACAPINAR (Necmettin Erbakan University, Türkiye)

fusunmireli@yahoo.com
ORCID: 0000-0001-7515-3851

Abstract

The aim of this study was to determine the effect of the problem-based learning method on students' academic achievement in mathematics lessons. A pre-test post-test control group experimental design was used to obtain the data of the study. The study was conducted in the 2021–2022 academic year in two classes, consisting of experimental and control groups, in Şarkikaraaaç Science High School in Isparta. Data were collected through an achievement test in the study. To prepare the achievement test, the objectives were determined, inserted into the table of test specifications, and expert opinion was obtained. Expert opinion was also obtained about the content validity. The overall reliability coefficient of the measurement tool was found to be 0,91 as KR-20. Descriptive statistics and independent and dependent group t-tests were used to analyse the data. According to the results of the research, it can be said that the problem-based learning method implemented in the 10th grade mathematic lessons improved the academic achievement of the students.

Keywords: *Academic achievement, Mathematics lesson, Problem-based learning*

Introduction

Mathematics has an important place in daily life and education (Soylu, Işık, & Konyalıoğlu, 2004). Mathematics plays an important role in solving problems encountered in daily life. The word "problem" here refers to the situations we call problems in daily life, rather than the problems solved in the mathematics lesson. The fact that mathematics is so important is effective in the emergence of mathematics in education at all levels, from pre-school to higher education. Although it is so important, students are afraid

of mathematics lessons in schools (Baykul, 2004). So, what are the reasons why students are afraid of mathematics lessons? Some studies have investigated the answer to this question in the literature (Başar & Doğan, 2020; Boz, 2008; Keklikci, 2011; Şenol et al., 2015). Among the reasons for students' fear of mathematics are the abstract nature of the lesson and the methods used in teaching mathematics (Şenol et al., 2015). Therefore, different teaching methods are needed to make the mathematics lesson more concrete and to enable students to understand better (Ministry of National Education [MEB], 2011).

In the rapidly changing and developing world, there is a need for individuals who follow innovations and changes and are aware of their own responsibilities. For these individuals to learn, it is not enough to transfer the knowledge by rote memorization (Şaşan, 2002). In this case, information is not acquired passively through senses or communication channels, on the contrary, it is actively acquired by the learner. It can be said that all these express the constructivist learning approach.

The constructivist learning approach is not a method but a theory of knowing. It offers views on how learning occurs (Çalışkan, 2018). Although it is not particularly interested in learning-teaching processes, it has revealed some results about these processes. Knowledge is created by the learner, and prior knowledge is believed to have an important place. Therefore, knowledge is specific to the individual. It is impossible to transfer information to another person. According to the constructivist learning approach, what teachers need to do is establish a relationship between the student and the curriculum and guide students in obtaining information (Açıkgöz, 2007). As mentioned above, although the constructivist learning approach is not a method or model, many methods and models adopt the constructivist learning approach (Tomooğlu & Kurtuluş, 2020). One of these methods is problem-based learning (Eroğlu et al., 2020; İnel, 2009; Tezci, 2002).

Problem-based learning is a method that prompts students to think and helps them solve the problems they encounter. Students embrace the problem by putting themselves in the shoes of problem solvers and taking an active role in the teaching process (Edens, 2000). In classrooms where problem-based learning is practiced, learners gradually become independent of their teachers and take responsibility for their learning (Kaptan & Korkmaz, 2001).

In problem-based learning, first, a problem is introduced. Then, the necessary information to solve the problem is collected by the students. By preparing an appropriate program, students are given opportunities to solve the problems they encounter (Woods, 1985). Problems posed in problem-based learning are not used for practice or practice after the subject. On the contrary, the prepared program is based on the problems chosen in line with the objectives. The selected problems should be real or similar to reality (Açıkgöz, 2007). Although there are some differences in the application of the problem-based learning process when the researches are examined, the studies are carried out with small student groups under the guidance of the teacher and by presenting the problems presented in the form of scenarios (Altıntaş, 2018; Cantürk Günhan, 2006; Kaptan & Korkmaz, 2001; Kara, 2020; Musal et al., 2002; Uslu, 2006; Usta, 2013). According to the learning objectives, the level of the students or the subject to be covered; scenario situations can be applied in one, two, or three sessions (Açıkgöz, 2007; Musal et al., 2002). Considering this information, the main stages in problem solving sessions are as follows (Açıkgöz, 2007; Kaptan & Korkmaz, 2001):

Session 1

- Creation of groups
- The distribution of the problem (scenario) to the groups
- Students identify the problem in the scenario and determine what they know and what they do not know.
- Determining the necessary information about the problem and assigning the task within the group.
- Helping students concentrate on important questions by the teacher
- Ending the session by summarizing the information about the problem.

Session 2

- Sharing the work done by the groups to solve the problem with other members of the group.
- Making arrangements regarding the work done in the 1st session, if necessary.
- Discussing the solution to the problem in the group and creating a common solution considering the information found.
- Presenting the information about the solution to the problem by the group
- Groups discussing with each other and comparing their results.
- Identifying deficiencies, discussing mistakes, and presenting new suggestions by students
- Summarizing and summarizing the results achieved by the groups

Problem-based learning is frequently applied in medical education (Açıkgöz, 2007; Musal et al., 2002). Although it is frequently applied in medical education, it is also used in other courses (Altıntaş, 2018; Cantürk Günhan, 2006; Eroğlu et al., 2020; İnel, 2009; Kaptan & Korkmaz, 2001; Öksüz & Uçan, 2011; Uslu, 2006). In this study, problem-based learning was applied to functions in mathematics lessons.

The subject of functions in the secondary education mathematics curriculum is one of the most basic subjects in mathematics. Functions form the basis of other topics. It is accepted as prior knowledge in teaching other subjects. In addition, students have difficulties in learning the subject of function and have misconceptions about the concept of function (Dede, 2006). Among the reasons why students have difficulty in learning the subject of function are the fact that the subject of the function is seen as confused by the students, the subject is not concrete, and they have difficulty in understanding the subject. In this case, problem-based learning can be used for functions in order to explain the function subject to the students more concretely and for the students to understand the subject more easily (Özgen & Pesen, 2008). At the same time, it is thought that the study will contribute to practitioners, namely mathematics teachers and researchers. By examining the study, mathematics teachers will be able to master how the lesson is

taught with a different approach in teaching the subject of functions, and they will be able to obtain clues on how problem-based learning can be applied to other mathematics subjects. It can be said that the study can be a guide for researchers when they want to conduct a study on similar subjects in this way. As a result, it is hoped that the study will be beneficial in terms of explaining the subject of functions to students in a more concrete and daily life-related way, helping mathematics teachers benefit from the application, and guiding researchers to conduct similar studies.

Various researches have been carried out on problem-based learning in different fields such as geometry, mathematics, science, technology, STEM education, and medicine (Çakır, 2015; Çetin & Mirasyedioğlu, 2019; İnel, 2009; Menten, 2019; Musal et al., 2002; Yavuz, 2019). There are many studies in the literature in terms of various variables in the mathematics course. These studies examine the effects of problem-based learning on academic achievement, attitude, self-efficacy, problem-solving skills, motivation, behavior, permanence in learning, geometry thinking level, and student views in mathematics lessons (Altıntaş, 2018; Alus, 2013; Aytaç, 2014; Cantürk Günhan, 2006; Eroğlu et al., 2020; Hatısaru, 2008; Karaalioğlu, 2016; Menten, 2019; Özgen & Pesen, 2008; Sezgin Selçuk et al., 2011; Uslu, 2006; Usta, 2013; Uyar & Bal, 2015; Uygun & Tertemiz, 2014).

In his master's thesis, Altıntaş (2018) examined how problem-based learning affects students' thinking of Van Hiele geometry at "Level 0", "Level 1" and "Level 2" on the subject of circles, circles and polygons. The researcher conducted an experimental study with secondary school seventh grade students. The study was carried out in two groups. Problem-based learning was used in a group and the existing program in the other. Before the application, the groups were pre-tested, and after the application, the post-test was applied to both groups. As a result, both applications at "Level 1" and "Level 2" benefited Van Hiele geometry thinking, but problem-based learning was more effective at "Level 0".

Alus (2013) examined the effect of problem-based learning on academic achievement and attitude in limit in his master's thesis. The researcher conducted an experimental study with two groups of students studying at the twelfth-grade level in a high school. Problem-based learning was carried out in one of the groups and teaching was carried out according to the existing program in the other group. Before and after the applications, both the achievement test and attitude scale were applied to both groups. At the end of the study, it was found that problem-based learning was more effective in terms of academic achievement, but no effect of problem-based learning was found in terms of attitude.

In his master's thesis, Aytaç (2014) investigated the effect of problem-based learning on sets on students' academic achievement and behaviour toward mathematics. The study was conducted with ninth-grade students studying at Anatolian High School. The research was carried out experimentally with two groups using pre- and post-tests. As a result, it was determined that the problem-based learning method had a significant positive effect on students' academic success and behaviour in mathematics.

Cantürk Günhan (2006) investigated the effects of problem-based learning about angles and polygons on students' attitudes, self-efficacy, academic achievement levels, critical thinking skills, and Van Hiele Geometry Thinking levels. In addition, the opinions of students, teachers, and faculty members about problem-based learning were also taken in the study. The research was conducted with students studying at the seventh-grade secondary school. It is both quantitative experimental and qualitative research. Because

of the research, it was concluded that the problem-based learning method increased students' attitudes, self-efficacy, academic achievement levels, critical thinking skills, and Van Hiele Geometry Thinking levels. In addition, the researcher stated that in the qualitative dimension of the research, the students wanted the problem-based learning method to be used in the lessons, the teachers had positive thoughts about this method, and the faculty members had positive opinions about the method.

In their study, Eroğlu et al. (2020) examined the effect of problem-based learning on students' achievements and attitudes about linear equations and inequalities. The study was conducted with eighth-grade secondary school students in two groups. Problem-based learning was applied in a group, and in the other, the application was made according to the current curriculum. As a result, problem-based learning significantly increased achievement and attitude.

Hatısaru (2008) examined the effect of problem-based learning on natural numbers and integers on students' achievements and attitudes in mathematics in his master's thesis. He also took the opinions of the students about problem-based learning. The research was conducted with students studying in the 9th grade in a vocational high school. As a result, it was concluded that problem-based learning increases success and attitude in mathematics in the quantitative dimension of the research, while in the qualitative dimension, the students found this method positive and expressed their opinion in favour of using it in the lessons.

In his master's thesis, Karaalioğlu (2016) examined how problem-based learning provides a change in student success and permanence of learning. In addition, students' opinions on the method were also taken. The study was conducted with students studying at the seventh-grade secondary school. Two groups were used in the study; problem-based learning was used in one group and application was made with existing methods in the other. Because of this research, it was determined that problem-based learning did not have a significant effect on success and permanence. Despite this, the scores of the student group in which the problem-based learning method was applied were higher than those of the other group. At the same time, student opinions on the method are generally positive.

In his master's thesis, Menten (2019) worked on polygons and quadrilaterals in the field of geometry learning with tenth grade students studying at Anatolian High School. In his study, the researcher examined the effect of problem-based learning on students' success, motivation, persistence, and attitude. At the same time, he also took student opinions on the method. Because of the research, the problem-based learning method increased students' attitudes, motivation, success, and permanence levels in learning. At the same time, in the qualitative dimension of the research, positive opinions of the students about the method were reached.

In their study, Özgen and Pesen (2008) examined the effect of problem-based learning about functions on students' success and learning retention levels. In addition, students' opinions on the method were also taken in the study. The study was conducted in two groups with students studying at the ninth-grade level in a high school. Problem-based learning was applied to one of the groups and the other was applied according to the existing teaching. As a result, problem-based learning significantly increased the success and retention of learning. It was also concluded that the opinions received from the students about the method were positive.

Sezgin Selçuk et al. (2011) carried out their study with mathematics teacher candidates studying in higher education on measurement and vectors. In this study, the effect of

problem-based learning on success in measurement and vectors was examined. Because of the study, the success in the group in which problem-based learning was applied was significantly higher than the success in the other group.

In his master's thesis, Uslu (2006) examined how the problem-based learning method on probability affects student success, attitude, and permanence in learning. The study was carried out in two groups with tenth grade students studying in a general high school. Problem-based learning was applied to one of the groups, while the other group was taught according to the current program. As a result, problem-based learning increases student achievement, retention level, and attitude toward learning.

Usta (2013) examined how the problem-based learning method on equations and inequalities affects students' self-efficacies, problem-solving skills, and success in his doctoral thesis. He also sought student opinions on the method. The research was conducted with students studying at the seventh-grade secondary school. It was concluded that the achievement, self-efficacy, and problem-solving skills of the students in the group in which the problem-based learning method was applied were significantly higher than those in the group in which the problem-based learning method was not applied. At the same time, it was determined that the students had positive opinions on the method.

Uyar and Bal (2015) conducted a study on natural numbers and sets with students studying at a sixth-grade secondary school. The research reveals the effect of problem-based learning on success and to determine students' opinions on the method. The study was carried out in two groups. Problem-based learning was applied to one group and the other group was taught according to the current program. As a result, while it was found that problem-based learning contributed significantly to success, it was concluded that students' opinions on the method were also positive.

Uygun and Tertemiz (2014) conducted studies with students studying at the 5th grade secondary school on the environment and space in their work. In this study, the effects of the problem-based learning method on students' success, permanence levels, and attitudes in learning was examined. The study was carried out in two groups. In conclusion, while there was no significant difference between the groups in terms of attitude, it was concluded that the problem-based learning method was more effective in terms of success and retention in learning.

When the literature is examined, it is seen that there are many researches on different topics in the mathematics course, but a limited number of researches on "functions" are made. With this research, it is aimed to contribute to the field by using problem-based learning about functions in mathematics lessons.

Purpose and Importance of the Research

In the rapidly developing and changing world conditions, the roles of students and teachers in education are also changing. What is expected from students now is not to passively receive information and memorize information but to be individuals who actively acquire information, assimilate and apply the learned information. The role of teachers, on the other hand, is not an authority that conveys information but a guide that guides students to acquire knowledge actively. For all these reasons, in this study, the effect of the problem-based learning method, which is a learning method that will enable students to acquire knowledge actively, on the achievement of students in the subject of "functions" in the 10th grade mathematics lesson was examined. The problem

statement determined in accordance with the purpose and the hypotheses to be tested depending on this problem statement are given below:

Problem Statement

Is there a significant difference between the post- and pre-test scores (reaches) of the groups in which problem-based learning is applied and not applied in the mathematics lesson?

Hypotheses

1. There was a significant difference between the pre- and post-test scores of the group in which problem-based learning was applied in the mathematics lesson.
2. There was a significant difference between the pre- and post-test scores of the group in which problem-based learning was not applied in the mathematics lesson.
3. There was a significant difference between the achievement scores of the groups in which problem-based learning was not applied in the mathematics course and the groups in which it was applied.

Method

Research Model

The study is experimental in quantitative dimension. The design of the research is schematized in Table 1. According to Karasar (2014), there is a comparison in experimental studies. This comparison can be in the form of changes within a method or comparing two different methods with each other. In this study, a comparison of two different methods applied in two different groups was made. For this reason, the pre-test post-test control group model, which is one of the experimental design types, was applied. In the model, groups are taken as they are in institutions. Appointment is not made by choice or chance. In addition, in experimental studies, the universe and the sample are not determined, but the study groups are determined. In these groups, it is important to balance them in terms of undesirable variables and not their size (Sönmez & Alacapınar, 2019).

In the research conducted to examine the effect of problem-based learning on the achievement of 10th grade secondary school students in teaching the subject of functions, problem-based learning and the methods and activities specified in the 2018 mathematics curriculum are the independent variables, and student achievement is the dependent variable. While teaching was carried out with problem-based learning in the experimental group, the methods and activities in the 2018 mathematics curriculum were used in the control group. Teaching time is equal to both groups, and it is 24 lesson hours for 4 weeks, 6 lesson hours a week. In the experimental group, first of all, the objectives were determined according to the "Bloom Taxonomy" in terms of functions, and the contents suitable for these objectives were arranged. These contents consist of problem scenarios and worksheets related to achievements prepared on the basis of problem-based learning. An example of a scenario is given in Appendix-1. Then, lesson plans suitable for problem-based learning were prepared by the researcher. In line with these plans, before starting the teaching, the students in the experimental group were informed about problem-based learning and the experimental group was taught lesson plans suitable for problem-based learning.

Table 1. Design of the Research

Groups	Pre-Test	Applied Method	Post-Test
Experiment	Function Test	Problem-Based Learning Implementation	Function Test
Control	Function Test	Methods and Activities in the Program of Teaching 2018 Mathematics	Function Test

Working group

While forming the study group for the experimental procedures, 55 students in 10-B and 10-D classes were recruited from the 10th grade of "Şarkikaraağaç Science High School" in Isparta province Şarkikaraağaç district in the 2020–2021 academic year. The experimental group was the 10-D class consisting of 28 people, and the control group was the 10-B class consisting of 27 people. The equivalences of these two groups in terms of gender, 9th grade mathematics course grades, and function test scores are examined below.

Table 2. Distribution of Students by Gender

Groups	Girl	Boy	Total
Experiment	17	11	28
Control	18	9	27

When Table 2 is examined, there are 17 female and 11 male students in the experimental group and 18 female and 9 male students in the control group. Considering the number of students, it is seen that there is not much difference between the groups. In this case, it can be said that the groups are equal in terms of gender.

In order to reveal the equivalence of the groups in terms of mathematics course achievement, the analyses made with the 9th grade mathematics course grades are shown in Table 3.

Table 3. T-test Results of Students' 9th Grade Mathematics reports Grades by Groups

Groups	n	$\bar{X}$	S	sd	t	p
Experiment	28	78,82	13,47	53	1,042	0,302
Control	27	74,90	14,42			

According to Table 3, there was no significant difference between the 9th grade mathematics course grades of the groups [t (53) = 1.042, p>0.05]. In that case, it can be said that the groups are equivalent in terms of 9th grade mathematics course grades.

The analyses made with the pre-test scores in order to reveal the equivalence of the groups in terms of their achievement in mathematics lesson functions are shown in Table 4.

Table 4. T-test Results of Students' Pre-Test Scores by Groups

Groups	n	$\bar{X}$	S	sd	t	p
Experiment	28	9,86	3,50	53	0,35	0,725
Control	27	9,44	5,04			

According to Table 4, there was no significant difference between the pre-test scores of the groups on mathematics course functions [t (53) = 0.35, p>0.05]. In that case, it can be said that the groups are equivalent in terms of pre-test mean scores.

Data Collection Tools

The data required to solve the sub-problems determined in accordance with the purpose of the study were obtained using the "Function Test" prepared for the 10th grade mathematics lesson functions. For the "Function Test", the objectives were determined and a table of specifications was prepared. 34 questions were prepared to measure achievements. Questions consist of multiple choice, fill-in-the-blank and open-ended questions. The opinions of three experts were taken to ensure the content validity of the prepared measurement tool. Arrangements were made within the framework of the opinions of the experts. The measurement tool was then applied to 100 students at the 10th, 11th, and 12th grade levels. In the evaluation of the measurement tool, correct answers were given a value of 1, and empty and incorrect answers were given a value of 0. Sample questions on the measurement tool are given in Appendix-2.

The KR-20 formula was used for the reliability of the measurement tool. According to Büyüköztürk et al. (2012), this formula is applied when "1" is given to the correct answers and "0" is given to the incorrect answers of the test items. The reliability coefficient of the function test prepared by the researcher was found to be KR-20 = 0.91. According to the KR-20 value found, it can be said that the function test is reliable.

Data Collection and Analysis

Before starting the study, the significance of the difference between gender status, 9th grade mathematics course grades, and pre-test scores of the students in the experimental and control groups was examined. The groups were balanced considering these data. Then, experimental and control groups were determined. Problem-based learning was applied to the students in the experimental group in line with the lesson plans prepared considering the achievements of the subject of functions. In order for students to learn the achievements about functions, problem scenarios and worksheets related to real life were prepared by the researcher in accordance with the problem-based learning method. Before starting to apply the prepared problem scenarios and worksheets, the students were divided into groups of 3-5 according to their wishes. Students were informed about the problem-based learning method. The students were given information about what to do during the lesson and how the lesson will be taught. In the control group, the lesson was taught using the methods and activities in the 2018 mathematics curriculum. A total of 24 lesson hours was taught for 4 weeks in groups. After the application was completed, the function test developed by the researcher and applied to the students before starting the study was repeated to the groups for the post-test.

In the analysis of the data obtained because of the study, descriptive statistics and dependent and independent group t-tests were used through the SPSS 26 program. To de-

termine the difference between the pre- and post-test scores of the experimental and control groups, the dependent groups t-test was analyzed. To determine the difference between 9th grade mathematics course grades, pre-test scores, and achievement scores of experimental and control groups, the t test was used for independent groups. The collected data and analysis to test the research hypotheses are summarized in Table 5 below:

Table 5. Data Used in Testing the Hypotheses and Analyses Made

Hypotheses	Data Used	Analysis Made
1	Experimental group pre-test post-test scores	t-test for dependent groups
2	Control group pre-test post-test scores	t-test for dependent groups
3	Experimental and control group achievement scores	t-test for independent groups

Findings

Findings Related to the First Hypothesis

The first hypothesis of the study is that "There is a significant difference between the pre- and post-test scores of the group in which problem-based learning was applied in the mathematics lesson." The dependent groups t-test was used to test the hypothesis. The T-test results are shown in Table 6.

Table 6. T-test Results According to the Pre- and Post-Test Scores of the Students in the Experimental Group

Groups	n	$\bar{X}$	S	sd	t	p
Pre-Test	28	9,86	3,50	27	-19,52	0,000
Post-Test	28	26,18	4,92			

Table 6 shows a significant difference in favour of the post-test because of the dependent groups t-test of the data obtained from the function test applied to the students before and after the subject of functions was taught in the group in which problem-based learning was applied in the mathematics lesson [t (27) =-19.52, p>0.05]. In this case, it can be said that problem-based learning effects students' achievement of functions in mathematics lessons.

Findings Related to the Second Hypothesis

The second hypothesis of the study is that "There is a significant difference between the pre- and post-test scores of the group in which problem-based learning was not applied in the mathematics lesson." The dependent groups t-test was used to test the hypothesis. T-test results are shown in Table 7.

Table 7. T-test Results According to the Pre- and Post-Test Scores of the Students in the Control Group

Groups	n	$\bar{X}$	S	sd	t	p
Pre-Test	27	9,44	5,04	26	-10,84	0,000
Post-Test	27	21,41	6,31			

Table 7 shows a significant difference in favour of the post-test because of the dependent groups t-test of the data obtained from the function test applied to the students before and after the subject of functions was taught in the group in which problem-based learning was not applied in the mathematics lesson [t (26) =-10.84, p>0.05]. In this case, it can be said that the method applied in the control group also has an effect on the students' achievement of functions in the mathematics lesson.

Findings Regarding the Third Hypothesis

The third hypothesis of the study is that "There is a significant difference between the achievement scores of the groups in which problem-based learning is not applied in the mathematics course and the groups in which it is applied." Independent groups t test was used to test the hypothesis. T-test results are shown in Table 8.

Table 8. T-test Results of Student Achievement Scores by Groups

Groups	n	$\bar{X}$	S	sd	t	p
Experiment	28	16,32	4,42	53	3,16	0,003
Control	27	11,96	5,73			

According to the results in Table 8, it has been determined that there is a significant difference in favour of the group where problem-based learning is used, between the mean achievement scores of students in the class where problem-based learning is used ($\bar{X}_{Experiment}$ = 16.32) and the mean achievement scores of students in the class where problem-based learning is not used ($\bar{X}_{Control}$ = 11.96) [t (53) = 3.16, p>0.05]. Therefore, it can be said that problem-based learning effects students' achievement scores in the topic of functions in mathematics.

Discussion, Conclusion and Suggestions

Here, considering the findings, the results of the research were determined, these results were discussed in terms of the application of the problem-based learning method in the mathematics course, and suggestions were developed depending on the results obtained. In the study, when the distributions by gender were examined, it was found that the groups were close to each other, and there was no significant difference between the 9th grade mathematics course grades of the experimental and control groups and the pre-application scores of the groups obtained from the function test. In this respect, it can be said that the groups are similar in terms of gender, report grades, and pre-test scores. Sönmez and Alacapınar (2019) stated that it is important to balance the groups in terms

of undesired variables in experimental studies. Because of these findings, it can be interpreted that the groups are balanced.

In the study, it was determined that there was a significant difference between the pre- and post - test scores in favour of the post-test scores both in the group in which problem-based learning was applied and in the group in which problem-based learning was not applied. Regardless of the method used for functions, teaching was carried out to the students in the end. As a result, it can be said that both methods affect student achievement. This is an expected situation. There are studies in the literature that support these results. Aytaç (2014) found a significant difference in favour of post-test scores in both problem-based learning and the current curriculum in his study on sets with ninth graders. Cantürk Günhan (2006), in his research on angles and polygons with secondary school seventh grade students, found that the post-test scores of the problem-based learning and current curriculum were significantly higher than the pre-test scores. Eroğlu et al. (2020) also reached the same conclusion in their study with eighth-grade students on linear equations and inequalities. At the same time, Özgen and Pesen (2008) worked with ninth grade students on functions, Sezgin Selçuk et al. (2011) on measurement and vectors with prospective mathematics teachers, Usta (2013) worked on equations and inequalities with seventh grade students in secondary school, Uygun and Tertemiz (2014) worked with secondary school fifth grade students on the subject of environment and space. All of them found significant differences in favour of post-testing in teaching with problem-based learning and current curriculum in their studies.

Although the current curriculum applied together with the problem-based learning method increases the achievement in terms of functions, the average of the achievement scores of the group (experimental group) in which the problem-based learning method is applied is significantly higher than the average of the achievement scores of the group (control group) in which the problem-based learning method is not applied. Because of the findings, although it can be said that both methods increase the achievement of functions in the mathematics course, it can be interpreted that problem-based learning increases the achievement more. Studies supporting this result we have obtained can be found in the literature. In his study, Alus (2013) stated that among the students studying at the twelfth-grade level on limit, those who were taught problem-based learning were more successful. Again, Cantürk Günhan (2006) reached the same conclusion with the seventh-grade students of secondary school on polygons with angles. In another study, Eroğlu et al. (2020) presented a parallel result with secondary school eighth grade students on linear equations and inequalities. At the same time, Menten (2019) studied geometry with tenth grade students in Anatolian high school on polygons and quadrilaterals, Özgen and Pesen (2008) on functions with ninth grades, Uslu (2006) on probability with tenth grade students in general high school, Usta (2013) on equations and inequalities with the seventh grade students, Uyar and Bal (2015) on natural numbers and sets with the sixth grade students, Uygun and Tertemiz (2014) on the environment and field with secondary school fifth grade students. All of them said that problem-based learning gave better results than the current curriculum. According to the research and findings of our study, it can be interpreted that problem-based learning is more effective than other methods in mathematics lessons.

According to the findings and results of the research, the following suggestions can be made.

1. When the researches made in the mathematics course with the problem-based learning method are examined, although there is sufficient research at the secondary

and high school level, enough research has not been done at the higher education level. Research can be conducted to address this deficiency in the literature.

2. When the research conducted in the mathematics lesson with the problem-based learning method was examined, studies were conducted on success, attitude, self-efficacy, persistence, motivation, student views, and Van Hiele geometry thinking levels. Studies can be conducted to examine how problem-based learning affects high-level thinking skills in mathematics.

3. When the studies conducted in the mathematics lesson with problem-based learning are examined, it is seen that the method generally increases the success, attitude, self-efficacy, persistence, and motivation of the students at every grade level in the mathematics lesson. In the context of this result, it can be suggested that practitioners, i.e., mathematics teachers, should use the problem-based learning method more frequently in their lessons.

References

Açıkgöz, K. Ü. (2007). *Aktif öğrenme [Active learning]*. İzmir: Biliş Yayıncılık.

Altıntaş, K. (2018). *Ortaokul 7. sınıf çember-daire ve çokgenler konularının öğretiminde probleme dayalı öğrenmenin öğrencilerin Van Hiele geometri düşünme düzeylerine etkisi [The effects of problem-based learning in teaching of secondary school 7th grade circle-rounds and polygons on students' Van Hiele geometry thinking levels]* (Tez No. 485963) [Yüksek lisans tezi, Gazi Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/

Alus, M. (2013). *Probleme dayalı öğrenme modelinin ortaöğretim öğrencilerinin matematik dersindeki akademik başarılarına etkisi [The effect of problem-based learning method on the academic achievement of secondary school students in maths]* (Tez No. 347501) [Yüksek lisans tezi, Necmettin Erbakan Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/

Aytaç, U. (2014). *Probleme dayalı öğrenmenin Anadolu liseleri matematik dersindeki kümeler konusunda öğrencilerin başarılarına ve davranışlarına etkisi [The effect of problem-based learning on students' achievements and behaviours about mathematical sets in Anatolian high schools]* (Tez No. 411476) [Yüksek lisans tezi, Yıldız Teknik Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/

Başar, M. & Doğan, M. C. (2020). Öğrencilerin matematik korkusunun incelenmesi [Investigation of students' fear of mathematics]. *Turkish Journal of Educational Studies, 7(3), 1–26.* https://dergipark.org.tr/tr/pub/turkjes/issue/57942/731145.

Baykul, Y. (2004). *İlköğretimde matematik öğretimi 6.-8. sınıflar için [Mathematics teaching in primary education 6.-8. for classes]*. Ankara: Pegem A Yayıncılık.

Boz, N. (2008). Matematik neden zor? [Why is mathematics difficult?] *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED), 2*(2), 52–65. https://dergipark.org.tr/tr/pub/balikesirnef/issue/3367/46489.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş. & Demirel, F. (2012). *Bilimsel araştırma yöntemleri [Scientific research methods]*. Ankara: Pegem Akademi.

Çakır, S. (2015). *7. sınıf matematik dersinde çember ve daire konusunun öğretiminde probleme dayalı öğrenme yönteminin öğrencilerin motivasyonlarına ve matematik kaygı düzeylerine etkisi [The effects of the problem-based learning method on the motivation and anxiety levels of the 7th grade mathematics students in the teaching of circumference and circle]* (Tez No. 397417) [Yüksek lisans tezi, Gazi Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Çalışkan, M. (2018). Öğrenme-öğretim model ve yaklaşımlar [Learning-teaching models and approaches]. M. Güçlü (Ed.), *Öğretim ilke ve yöntemleri [Teaching principles and methods]* içinde (s. 185–235). Ankara: Maya Akademi Yayınevi.

Cantürk Günhan, B. (2006). *İlköğretim II. kademede matematik dersinde probleme dayalı öğrenmenin uygulanabilirliği üzerine bir araştırma [An investigation on applicability of problem-based learning in the mathematics lesson at the second stage in the elementary education]* (Tez No. 206025) [Doktora tezi, Dokuz Eylül Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Çetin, Y. & Mirasyedioğlu, Ş. (2019). Teknoloji destekli probleme dayalı öğretim uygulamalarının matematik başarısına etkisi [The effects of the technology supported problem-based learning activities on students' achievement in mathematics]. *Journal of Computer and Education Research, 7*(13), 13–34. https://doi.org/10.18009/jcer.494907.

Dede, Y. (2006). Mathematics educational values of college students' towards function concept. *Eurasia Journal of Mathematics, Science and Technology Education, 2*(1), 82–102. https://doi.org/10.12973/ejmste/75440.

Edens, K. M. (2000). Preparing problem solvers for the 21st century through problem-based learning. *College Teaching, 48*(2), 55–60. https://doi.org/10.1080/87567550009595813.

Eroğlu, A., Aydoğdu, M. & Tutak, T. (2020). Doğrusal denklemler ve eşitsizlikler konusunun öğretiminde probleme dayalı öğrenme yaklaşımının öğrenci başarısına ve tutumuna etkisi [The effect of problem-based learning approach on student achievement and attitude in teaching linear equations and inequalities]. *Elektronik Eğitim Bilimleri Dergisi [Electronic Journal of Education Sciences], 9*(18), 97–108.

Hatısaru, V. (2008). *Probleme dayalı öğrenme yönteminin endüstri meslek lisesi dokuzuncu sınıf öğrencilerinin matematik dersi başarılarına ve matematiğe yönelik tutumlarına etkisi [The effect of problem-based learning method on ninth grade industrial vocational high school students' success in mathematics course and their attitudes towards mathematics]* (Tez No. 232253) [Yüksek lisans, Başkent Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

İnel, D. (2009). *Fen ve teknoloji dersinde probleme dayalı öğrenme yöntemi kullanımının öğrencilerin kavramları yapılandırma düzeyleri, akademik başarıları ve sorgulayıcı öğrenme becerileri algıları üzerindeki etkileri [The effects of using problem-based learning method in science and technology lessons on students' level of constructing concepts, academic achievement and perceptions of inquiry learning skills]* (Tez No. 239333) [Yüksek lisans, Dokuz Eylül Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Kaptan, F. & Korkmaz, H. (2001). Fen eğitiminde probleme dayalı öğrenme [Problem-based learning in science education]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, (20), 185–192.

Kara, A. (2020). *Doğrusal denklemler ve eşitsizlikler konusunun öğretiminde probleme dayalı öğrenme yaklaşımının öğrenci başarısına ve tutumuna etkisi [The effect of problem-based learning approach on student achievement and attitude in teaching the subject of linear equations and inequalities]* (Tez No. 636865) [Yüksek lisans, Fırat Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Karaalioğlu, A. (2016). *7. sınıf oran ve orantı konusunun probleme dayalı öğrenme yaklaşımı ile öğrenci başarı ve kalıcılığına etkisi [The effect of the 7th grade ratio and proportion subject on student success and retention with the problem-based learning approach]* (Tez No. 456605) [Yüksek lisans, Ondokuz Mayıs Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Karasar, N. (2014). *Bilimsel araştırma yöntemi [Scientific research method]*. Ankara: Nobel Akademik Yayıncılık.

Keklikci, H. (2011). *İlköğretim öğrencilerinin matematik korkuları üzerine bir araştırma [A study on primary school students' math fears]* (Tez No. 296468) [Yüksek lisans, Gaziosman Paşa Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

MEB. (2011). *Ortaöğretim matematik dersi öğretim programı [Secondary school mathematics curriculum]*. Ankara: MEB. 10.01.2022 tarihinde https://ttkb.meb.gov.tr/ adresinden edinilmiştir.

Menten, G. (2019). *Probleme dayalı öğrenme yaklaşımının onuncu sınıflarda geometriye ilişkin akademik başarı, kalıcılık, tutum ve motivasyona etkisi [The effect of problem-based learning approach on academic achievement, retention, attitude and motivation related to geometry in tenth grades]* (Tez No. 588429) [Yüksek

lisans, Çukurova Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Musal, B., Akalın, E., Kılıç, O., Esen, A. & Alıcı, E. (2002). Dokuz Eylül Üniversitesi Tıp Fakültesi probleme dayalı öğretim programı, süreçleri ve eğitim yönlendiricilerinin rolü [Dokuz Eylül University Faculty of Medicine problem-based curriculum, processes and the role of educational facilitators]. *Tıp Eğitimi Dünyası*, *9*(9), 39–49.

Öksüz, C. & Uçan, S. (2011). Matematik dersinde probleme dayalı öğrenme üzerine bir örnek olay [A case study on problem-based learning in mathematics]. *Adnan Menderes Üniversitesi Eğitim Fakültesi Eğitim Bilimleri Dergisi*, *2*(2), 20–29. https://dergipark.org.tr/tr/pub/aduefebder/issue/33887/375222.

Özgen, K. & Pesen, C. (2008). Fonksiyon konusunun öğretiminde probleme dayalı öğrenme yaklaşımının öğrencilerin akademik başarı ve hatırda tutma düzeyine etkisi [The effect of problem-based learning approach in teaching function subject on students' academic achievement and retention level]. *Education Sciences*, *3*(3), 505–522. https://dergipark.org.tr/tr/pub/nwsaedu/issue/19831/212501.

Şaşan, H. H. (2002). Yapılandırmacı öğrenme [Constructivist learning]. *Yaşadıkça Eğitim*, (74–75), 49–52. http://journals.iku.edu.tr/yed/index.php/yed/issue/view/89/86.

Şenol, A., Dündar, S., Kaya, İ., Gündüz, N. & Temel, H. (2015). Ortaokul matematik öğretmenlerinin matematik korkusu ile ilgili görüşlerinin incelenmesi [Examination of secondary school mathematics teachers' views on fear of mathematics]. *Eğitimde Kuram ve Uygulama*, *11*(2), 653–672. https://dergipark.org.tr/tr/pub/eku/issue/5465/74216.

Sezgin Selçuk, G., Karabey, B. & Çalışkan, S. (2011). Probleme dayalı öğrenmenin matematik öğretmen adaylarının ölçme ve vektörler konularındaki başarıları üzerindeki etkisi [The effect of problem-based learning on pre-service mathematics teachers' achievement in measurement and vectors]. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *8*(15), 313–322. https://dergipark.org.tr/tr/pub/mkusbed/issue/19555/208674.

Sönmez, V. & Alacapınar, F. G. (2019). *Örneklendirilmiş bilimsel araştırma yöntemleri [Illustrated scientific research methods]*. Ankara: Anı Yayıncılık.

Soylu, Y., Işık, A. & Konyalıoğlu, A. C. (2004). Eğitim fakülteleri sınıf öğretmenliği programında okutulan matematik derslerinin ilköğretim matematik müfredatına uygunluğu [The suitability of the mathematics courses taught in the primary school teaching program of education faculties with the primary school mathematics curriculum]. *Kastamonu Eğitim Dergisi*, *12*(1), 117–124.

Tezci, E. (2002). *Oluşturmacı öğretim tasarım uygulamasının ilköğretim beşinci sınıf öğrencilerinin yaratıcılıklarına ve başarılarına etkisi [The effect of constructivist instructional design practice on the creativity and achievement of fifth grade*

primary school students] (Tez No. 122017) [Doktora tezi, Fırat Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Tomooğlu, Ö. & Kurtuluş, A. (2020). Altıncı sınıfta üçgen ve paralelkenarın alanını ölçmeye yönelik 5E öğretim modelinin kullanılması: Bir eylem araştırması [Using the 5E teaching model to measure the area of triangle and parallelogram in sixth grade: An action research]. *Eskişehir Osmangazi Üniversitesi Türk Dünyası Uygulama ve Araştırma Merkezi (ESTÜDAM) Eğitim Dergisi*, *5*(2), 184–205.

Uslu, G. (2006). *Ortaöğretim matematik dersinde probleme dayalı öğrenmenin öğrencilerin derse ilişkin tutumlarına, akademik başarılarına ve kalıcılık düzeylerine etkisi [The effect of problem-based learning in secondary school mathematics course on students' attitudes towards the course, academic achievement and retention levels]* (Tez No. 180130) [Yüksek lisans, Balıkesir Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Usta, N. (2013). *Probleme dayalı öğrenmenin ortaokul öğrencilerinin matematik başarısına, matematik özyeterliğine ve problem çözme becerilerine etkisi [The effect of problem-based learning on middle school students' mathematics achievement, mathematics self-efficacy and problem solving skills]* (Tez No. 333558) [Doktora tezi, Gazi Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Uyar, G. & Bal, A. P. (2015). 6. sınıf öğrencilerinde probleme dayalı öğrenmenin akademik başarıya etkisi [The effect of problem-based learning on academic achievement in 6th grade students]. *Pegem Eğitim ve Öğretim Dergisi*, *5*(4), 361–374. https://doi.org/10.14527/pegegog.2015.020,

Uygun, N. & Tertemiz, N. I. (2014). Matematik dersinde probleme dayalı öğrenmenin öğrencilerin derse ilişkin tutum, başarı ve kalıcılık düzeylerine etkisi [The effect of problem-based learning in mathematics course on students' attitudes towards the course, achievement and retention levels]. *Eğitim ve Bilim*, *39*(174), 75–90. http://dx.doi.org/10.15390/EB.2014.1975.

Woods, D. R. (1985). What about problem-based learning? *Journal of College Science Teaching, 15*(1), 62–64. http://www.jstor.org/stable/42992012.

Yavuz, M. (2019). *Problem temelli STEM etkinliklerinin oran-orantı ve yüzdeler konularının öğretiminde 7.sınıf öğrencilerinin matematik başarılarına, tutumlarına ve görüşlerine etkisi [The effect of problem-based STEM activities on the mathematics achievement, attitudes and opinions of 7th grade students in the teaching of ratio-proportion and percentages]* (Tez No. 556387) [Yüksek lisans, Erciyes Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/.

Appendix-1. A Scenario Example Created According to the Problem-Based Learning Applied in the Experimental Group

Scenario-1
Ali, Fatih, Mehmet, Hamdi, Ferdi and Murat donate blood in the hospital to learn their blood types. After a certain period of time, blood groups become clear. The files containing the blood groups are mixed by the nurse. The nurse needs to find the blood groups of the right people. Therefore, the papers with the names Ali, Fatih, Mehmet, Hamdi, Ferdi and Murat were put aside. On the other side, papers on which A Rh (+), A Rh (-), 0 Rh (+) and 0 Rh (-) blood groups were written were placed. What can be done so that the nurse can match blood types and people correctly?

a) Indicate the problem situation?

b) How can people's names and blood types match?

c) Is it possible for all people to have the same blood groups?

d) Is it possible for all people to have different blood types?

e) Discuss and define the concept of function as a group?

f) Define the function in this case and give an example?

g) Write the definition, value and display sets of the function you defined in this event?

Appendix-2. "Functions Test" Sample Questions

Fill in the blanks below with the correct terms.

- The relation that maps each element of A to one and only one element in B, where A and B are two non-empty sets is called .....
- The set of "input" values for which a function is defined is called .....
- The set of "output" values for which a function is defined is called .....
- The set formed as a result of matching the "input" values of a function with the "output" values is called .....

- This test is applied to determine whether a relation whose graph is given is a function. It is called .....
- Functions are special .....

Answer the questions given below.

- Write the definition and value set in the expression $f : A \rightarrow B$.
- Write what x and y mean in the expression $y = f(x)$.

- Image set, functions equal to the value set are called covering functions.
- A function can be both an encapsulating and a covering function.
- In one-to-one functions, the images of any two elements taken from the domain are not equal.
- Constant functions are both even and odd functions.
- Functions with straight graphs are called linear functions.
- f(x)=x is the unit function.

How many of the above statements are correct?
A) 2 **B)** 3 **C)** 4 **D)** 5 **E)** 6