THE EFFECTS OF PROBLEM SOLVING ON THE TOPIC OF FUNCTIONS ON PROBLEM SOLVING PERFORMANCE, ATTITUDE TOWARD PROBLEM SOLVING AND MATHEMATICS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

BİLGEN EGE ÖZALKAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
SECONDARY SCIENCE AND MATHEMATICS EDUCATION

MAY 2010

Approval of the thesis:

THE EFFECTS OF PROBLEM SOLVING ON THE TOPIC OF FUNCTIONS ON PROBLEM SOLVING PERFORMANCE, ATTITUDE TOWARD PROBLEM SOLVING AND MATHEMATICS

submitted by **BİLGEN EGE ÖZALKAN** in partial fulfillment of the requirements for the degree of
Master of Science in Secondary Science and Mathematics Education Department, Middle East Technical University by,

Prof. Dr. Canan ÖZGEN _____
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Ömer GEBAN _____
Head of Department, **Secondary Science and Mathematics Education**

Assoc. Prof. Dr. Safure BULUT _____
Supervisor, **Secondary Science and Mathematics Education Department**

Examining Committee Members:
Assoc. Prof. Dr. Renan SEZER _____
EME, Hacettepe University

Assoc. Prof. Dr. Safure BULUT _____
SSME, METU

Assoc. Prof. Dr. Ahmet ARIKAN _____
SSME, Gazi University

Assoc. Prof. Dr. Yezdan BOZ _____
SSME, METU

Assist. Prof. Dr. Mine IŞIKSAL _____
EME, METU

Date: _____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: BİLGEN EGE ÖZALKAN

Signature :

ABSTRACT

THE EFFECTS OF PROBLEM SOLVING ON THE TOPIC OF FUNCTIONS ON PROBLEM SOLVING PERFORMANCE, ATTITUDE TOWARD PROBLEM SOLVING AND MATHEMATICS

Özalkan, Bilgen Ege

M.S., Department of Secondary Science and Mathematics Education

Supervisor : Assoc. Prof. Dr. Safure BULUT

May 2010, 101 pages

The purpose of the study was to investigate the effect of Problem Solving Method on 9th grade students' problem solving performance and attitudes toward mathematics and problem solving. This study was done in 2007-2008 academic year, in a private high school in Ankara. In the present study the experimental-control group pre-test post-test research design was used.

The study was done with 67 students of the private high school. Experimental group was instructed with Problem Solving Method and control group was instructed with Traditional Method. The treatment was given for seven weeks, 21 lesson hours.

Problem Solving Performance Test, Problem Solving Attitude Scale and Mathematics Attitude Scale were administered as a pre test and a post test.

Independent samples t-test was used to examine the hypotheses of the present study. The results revealed that there were no statistically significant mean differences between

experimental group and control group related to gained scores of understanding the problem, making a plan and carrying out the plan steps in Problem Solving Performance Test and Mathematics Attitude Scale. However, there was a statistically mean difference between these groups with respect to gained scores of Problem Solving Attitude Scale.

Keywords: Problem Solving Method, performance, attitude, functions

ÖZ

FONKSİYONLAR KONUSUNDA PROBLEM ÇÖZME YÖNTEMİNİN

PROBLEM ÇÖZME PERFORMANSINA, PROBLEM ÇÖZME VE MATEMATİĞE

YÖNELİK TUTUMLARA ETKİSİ

Özalkan, Bilgen Ege

Yüksek Lisans, Fen ve Matematik Alanları Eğitimi Bölümü

Tez Yöneticisi : Doç. Dr. Safure BULUT

Mayıs 2010, 101 sayfa

Çalışmanın amacı dokuzuncu sınıf öğrencilerinin problem çözme performansları ile matematiğe ve problem çözmeye yönelik tutumlarını incelemektir. Çalışma 2007-2008 öğretim yılında Ankara'daki bir özel lisede yapılmıştır. Bu çalışmada deney grubu-kontrol grubu ön test-son test araştırma deseni kullanılmıştır..

Çalışma 67 özel lise öğrencisi ile yapılmıştır. Deney grubunda problem çözme yöntemi, kontrol grubunda geleneksel yöntem ile ders işlenmiştir. Uygulama 7 hafta, 21 ders saati sürmüştür.

Problem Çözme Performans Testi, Problem Çözmeye Yönelik Tutum Ölçeği ve Matematiğe Yönelik Tutum Ölçeği ön test ve son test olarak uygulanmıştır.

Bu çalışmanın hipotezlerini analiz etmek için bağımsız örneklem t-testi kullanılmıştır. Bu analizin sonucunda deney ve kontrol grupları arasında Problem Çözme Performans

Testi'ndeki problem anlama, plan yapma ve uygulama adımlarından ve Matematiğe Yönelik Tutum Ölçeği'nden elde ettikleri kazanç puanların ortalamalarına göre istatistiksel olarak anlamlı farklar olmadığını ortaya çıkarmıştır. Bununla birlikte, bu gruplar arasında Problem Çözmeye Yönelik Tutum Ölçeği'nden elde ettikleri kazanç puanların ortalamalarına göre istatistiksel olarak anlamlı bir fark bulunmuştur.

Anahtar Kelimeler: Problem çözme yöntemi, performans, tutum, fonksiyonlar

to Eren...

ACKNOWLEDGMENTS

I am heartily thankful to my advisor Assoc. Prof. Dr. Safure Bulut for her support, encouragement and patience throughout the study.

I owe my deepest gratitude to my family; Erhan Özalkan for his motivated words, Gönül and Ayka Ege for their guidance, and my little baby Eren Özalkan for his patience; he shared his mother with this thesis.

I am grateful to my dearest brother Barış Ege... without his motivation I could not finish this thesis.

I would like to thank my colleagues Dr. Sefa Yıldız Uğurlu, Meral Aksoy and Seçkin Karaaslan for their valuable help and support.

I also would like to thank my all students for their collaboration.

Finally, I'm also thankful to Prof.Dr. Suzan Kıncal, I cannot forget the motivation and support she gave me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CG: Control Group

EG: Experimental Group

PSM: Problem Solving Method

TM: Traditional Method

PSPT: Problem Solving Performance Test

PSAS : Problem Solving Attitude Scale

MAS: Mathematics Attitude Scale

UEE: University Entrance Exam

TIMSS: Trends in International Mathematics and Science Study

PISA: Programme for International Student Assessment

MoNE: Ministry of National Education

TD: Tebliğler Dergisi

NCTM: National Council of Teachers of Mathematics

CHAPTER 1

INTRODUCTION

Problem solving is an important aspect in the field of mathematics education. However, the space reserved for problem solving in high school mathematics curriculum in Turkey is limited (Ministry of National Education, 2005; Tebliğler Dergisi, 1974). The importance of problem solving mentioned in more detail in the second level of primary school mathematics curriculum in Turkey (MoNE, 2005).

Mathematical problem is a situation which requires challenge and decision making (Krulik & Posementier, 1998). Most of the research studies state that problem solving skills are improved when students construct a new problem ("problem posing") (English, 1997; Lavy & Bershadsky, 2003). However, problem posing is one of the significant parts of mathematics education; the present study does not include it. Problem posing method could not be integrated a study which is on problem solving.

The mathematics teachers know the importance of mathematics and problem solving; therefore their decisions are parallel with the curriculum on problem solving (Kayan, 2007). Although there is an important series of general exams (SBS, ÖSS, etc.) in Turkey, teachers do not want to teach mathematics through multiple-choice items; which the general exams consist of multiple-choice items. Teachers expect their students to solve problems step by step, and they want to give priority to the problem solving process instead of finding just the solution (Kayan, 2007). According to the teachers' ideas on mathematics education, one of the main purposes of the research studies on the high school curriculum should be to find out

how to integrate Problem Solving Method on high school curriculum in a connection with primary school mathematics curriculum.

There are various studies which are focused on problem solving not only in Turkey, also in the world (e.g. Hanley, 1995; Kandemir, 2006; Koç, 1998; Mayo, 1994; McLoad, 1989; Özkaya, 2002; Yavuz, 2006; Yıldız, 2008; Yılmaz, 2007). Some of the studies showed that Problem Solving Method is one of the most effective methods in mathematics education (e.g. Hanley, 1995; Koç, 1998; Özkaya, 2002). Hence, mathematics attitude and/or problem solving attitude are important in the literature (Akman, 2005; Hanley, 1995; Kandemir, 2006; Koç, 1998; Mayo, 1994; McLoad, 1989; Özkaya, 2002). In Turkey there are some studies which are similar to each other. The researchers are generally interested in problem solving (Kandemir, 2006; Koç, 1998; Özkaya, 2002; Yavuz, 2006; Yıldız, 2008; Yılmaz, 2007). They used problem solving steps of Polya and problem solving strategies. There are studies on problem solving in a vide area of titles and subtitles of mathematics.

Similar to other studies, this study prepared based on students' problem solving performance. The subject was chosen as "functions" in the study. The study includes the change of students' problem solving performance, attitudes toward problem solving, and mathematics. The participants were in 9^{th} grade in 2007-2008 academic year, when the study was being conducted. The 9^{th} grade students had no idea about problem solving when they had come to the high school.

1.1 Purpose of the Study

The purpose of this study was to investigate the effect of Problem Solving Method on 9^{th} grade students' problem solving performance on functions, attitudes toward mathematics and problem solving.

1.2 Problem of the Study

Main problem of the study was stated as "What is the effect of Problem Solving Method on 9^{th} grade students' problem solving performance on Functions, attitudes toward mathematics and problem solving?"

To examine the main problem, three sub-problems were stated:

S1: What is the effect of Problem Solving Method on 9th grade students' problem solving performance on Functions?

S2: What is the effect of Problem Solving Method on 9th grade students' attitudes toward problem solving?

S3: What is the effect of Problem Solving Method on 9th grade students' attitudes toward mathematics?

To examine the main problem, five null hypotheses were stated below. They were tested at the significance level .05.

To investigate the first sub-problem, following null hypotheses were stated:

H_0 1.1: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "understanding the problem" step.

H_0 1.2: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "making a plan" step.

H_0 1.3: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "carrying out the plan" step.

To investigate the second sub-problem, following null hypothesis was stated:

H_0 2.1: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude towards problem solving.

To investigate the third sub-problem, following null hypothesis was stated:

H_0 3.1: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude towards mathematics.

1.3 Definition of Terms

Problem: "A problem is a situation that confronts a person, that requires resolution, and for which the path to the solution is not immediately known."(Krulik & Posamentier, 1998, p.1)

Problem refers to a situation which is different from routine exercises and the drilling questions whose solution procedure is known commonly. When a situation is called as problem, this situation is required challenge and use of common knowledge. (Krulik & Rudnick, 1987; MoNE, 2005; Posamentier & Stepelma, 2002; Zeitz, 1999)

Problem Solving: Hunt(1994) describes problem solving like beauty, good art, these things had common property that we could see them and feel them but we cannot define them. Problem solving is a challenging and intelligent process to take the person to the exact result.

Problem solving strategies refer to a number of strategies that are used in the process of solving the problem (Krulik & Rudnick, 1987) such as working backwards, finding a pattern, adopting a different point of view, solving a simpler, analogous problem, considering extreme cases, making a drawing, intelligent guessing and testing, accounting for all possibilities, organizing data, logical reasoning (Krulik & Rudnick, 1987), and deriving an equation (MoNE, 2005).

Problem Solving Method: It refers to teaching mathematics by using problems and problem solving strategies. There are four problem solving steps according to Polya (1973): 1.Understanding the problem; 2.Making a plan; 3.Carrying out the plan; 4.Looking back and extend

Performance on Understanding the Problem: It refers to the score obtained from the understanding the problem step in Problem Solving Performance Test.

Performance on Making a Plan: It refers to the score obtained from the making a plan step in Problem Solving Performance Test.

Performance on Carrying out the Plan: It refers to the score obtained from the making a plan step in Problem Solving Performance Test.

Problem Solving Performance: It refers to the students' scores when they are solving problems in Problem Solving Performance Test.

Traditional Method: It refers to a teacher centered teaching method. Traditional Method required lecture and question-answer parts.

Experimental Group: It refers to a group of students who are taught by Problem Solving Method.

Attitude: "Your attitude toward something is the way that you think and feel about it" (Sinclair, 1993, p.81).

Attitude Toward Problem Solving: It refers the scores obtained from Problem Solving Attitude Scale.

Attitude Toward Mathematics: It refers the scored obtained from Mathematics Attitude Scale.

Control Group: It refers to a group of students who are taught by Traditional Method.

Placement Test: It refers to a test be given to the 9^{th} grade students by the administration to determine their success at the beginning of the academic year to assign their classes.

Gained score: The score obtained from the difference between student's pre-test and post-test scores.

1.4 Significance of the Study

An objective eye could easily see the place of Turkish Students in the world according to their success in problem solving. When we look at the results of Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA), which are assessment systems worldwide, we could see the real place of Turkish Students over the ones in the world.

According to PISA and TIMSS reports, Turkish Students could not learn problem solving. The place of Turkish Students in TIMSS shows that Turkish Teachers should think about teaching in a right way. There were only 1% of Turkish Students in the higher 10% of the whole in problem solving (MoNE-EARGED, 2003). The place of Turkish Students in PISA is not different from that of TIMSS. According to PISA 2003, 75% of the Turkish Students were unsuccessful in the 2nd level of mathematical thinking (MoNE-EARGED, 2005).

In 1999 TIMSS searched 8th grade mathematics achievement . Turkish Students took place in 25th percentile with 65% of the students, and 90th percentile with 1% of the students at mathematical achievement (MoNE-EARGED, 2003). Moreover, Turkish Students' mathematics achievement mean is 429, where the international average is 487 in TIMSS 1999. That result shows that Turkish Students were unable to solve mathematical problems when they are compared to the students from other countries.

There is a similar result for PISA 2003. PISA results showed that about 75% of fifteen-year old Turkish Students were in 2nd stage or below in Mathematics ability (MoNE-EARGED, 2005). That means Turkish Students could only solve problems which are simple and knowledge level, because in PISA 2003 there were 6 stages of Problem solvers. If we compare Turkish Students with the students from other countries, Turkish Students' percentage of being 5th or 6th stage is very low (MoNE-EARGED, 2005). Moreover, Turkish Students' mean is 423, where the OECD average is 489. That result shows that Turkish Students are not good problem solvers. It is easily seen that Turkish Students could not increase their success in both mathematical problem solving, and mathematics from 1999 to 2003.

It is possible to analyze TIMSS and PISA results together, because in Turkey 8th graders are generally fourteen or fifteen year-old students. Educational politics and objectives are needed to be changed with respect to the results explained above. This study focused on the progress of problem solving performances of the students.

Another aspect of Turkish Students' problem solving success is University Entrance Examination in Turkey. UEE results show that Turkish Students' success in mathematics is lower than their social-sciences success. Table 1.4.1 shows means and standard deviations of

each Mathematics test of UEE (ÖSS) from 2003 to 2007 where the mathematics test had 30 items each year.

Table 1.4.1: UEE results for mathematics tests from 2003 to 2007

Year	Mean	SD
2003	10.1	12.9
2004	7.9	11.1
2005	7.5	11.5
2006	8.5 (Mat1)	8.4 (Mat1)
	7.0 (Mat2)	6.6 (Mat2)
2007	8.6 (Mat1)	9.1(Mat1)
	6.5 (Mat2)	7.9 (Mat2)

As it could be seen in Table 1.4.1, means of the mathematics tests were in 6.5-10.5 scale over 30 items. The mean scores of the UEE were in decreasing trend in 2004 and 2005 because of the change in concept of mathematics items, number of problems had been increased in mathematics test from 2004. After 2005, the university entrance system had been changed and two different tests were used to test the students' mathematics success. First test included basic mathematics limited 9^{th} grade curriculum and second test included higher grades mathematics items with real life problems. Those results showed that Turkish Students' success in mathematics decreased according to the percentage of problems over other items of the mathematics test.

Knowing mathematics includes understanding specific concepts and procedures as well as the process of doing mathematics (NCTM, 1991). In the Turkish high school mathematics curriculum, it was mentioned that global changes required some research studies on the education. These research studies defined a new vision of mathematics education. The

students' abilities on thinking critically and creatively, modeling, problem solving, etc were some of the changes in the new vision of the mathematics curriculum (MoNE, 2005). Another important thing in the new curriculum was to adopt the students for real life. The way to getting used to real life, one of the good ways was expressed as learning problem solving in the (MoNE, 2005). It should be asked how to increase students' performance in problem solving. Answer of this question was the main point of the studies in Turkey (e.g. Kandemir, 2006; Kayan, 2007; Kertil, 2008; Koç, 1998; Özkaya, 2002; Yavuz, 2006; Yıldız, 2008; Yılmaz, 2007). These studies included different methods of mathematics teaching and different subjects of mathematics and they were applied to different kinds of participants. Koç (1998) did his research on 7th grade students' problem solving performance. Özkaya (2002) studied high school students' problem solving performance on geometry. Yavuz (2006) studied the progress on the 9th grade students' affective domain and achievement after teaching problem solving. Yıldız (2008) searched the effect of teaching mathematics through problem solving steps in 6th grade. Kayan (2007) and Kertil (2008) studied on teachers' beliefs on problem solving. They noticed the importance of the teachers' ideas about the teaching method they use.

As it could be seen above, problem solving was point of origin a lot of studies. However the studies were generally based on elementary school students (e.g. Koç, 1998; Özsoy, 2007; Yıldız, 2008), the 9th grade students' problem solving performances had been searched by some researchers (e.g.Yavuz, 2006). Similar to Akman's study (2005), this one was applied to 9th grade students when they were taught the subject "functions" whereas Problem Solving Method was chosen as the teaching method. Participants of this study were 9th grade students. The ninth grade students' problem solving performances, attitudes toward problem solving and mathematics were examined in this study.

CHAPTER 2

LITERATURE REVIEW

In this chapter there is review of literature related with this study.

2.1 Problem Solving Method

There is related literature to identify some important terms of this study problem, problem solving and Problem Solving Method.

2.1.1 Problem

Krulik and Posamentier (1998) defined problem as "a situation that confronts a person, that requires resolution, and for which the path to the solution is not immediately known" (p.1). This definition shows that if a situation is called a "problem" there should be a challenge to solve it. If the solution is known, there would not be any "problem". A student must think and find the relations between the subjects and methods to solve a problem.

According to Zeitz's (1999) words about the difference between exercise and problem, the following could be said: An exercise is a question which can be solved immediately. When solving an exercise, a person does not need applying specific techniques or puzzling out choosing techniques to use. On the other hand, a problem requires thinking skills and resourcefulness before the right approach is found. Supporting Zeitz's words Sakshaug et al. (2002) expressed that a specific type of problem must be used once. If a problem is used more than one, it becomes an exercise. He mentioned that the opposite statement is possible also. A question, which requires challenge and usage of knowledge which are recently learned, could be a problem if the students meet that for the first time. It should be mentioned that problems which are used in this study were like explained above. They were questions

related with “functions” and required challenge and thinking skills and usage of special techniques. These problems were new for the students.

After explaining the “problem” with its importance and meaning in this study, the explanation of “problem solving” takes place. However problem solving seems to be required problem itself, problem should be understood before problem solving is mentioned.

2.1.2 Problem Solving

National Council of Teachers of Mathematics (NCTM) explains problem solving as cope a situation which is first seen at that time and does not have immediate answer (NCTM, 2000). Also Turkish Ministry of Education expresses problem solving in the high school mathematics curriculum. It is stated that problem solving is not a specific subject or algorithm of solving a problem; it has to be defined as a process of finding the solution to a problem by using challenge (MoNE, 2005).

Özkaya (2002) states that, problem solving is considered as a function of transferring tasks that were previously learned. A person should know the subject well if he wants to solve a problem related to that subject. However she mentions that students tend to do the same or similar things to solve problems. That is not actually problem solving. Teachers generally choose to do the repetition of strategies for problem solving by huge number of examples. Holton (1994) did not think that way. He suggested the teachers to let their students to learn various techniques of problem solving, not the problem itself. In this way students could use the techniques by themselves. Indeed Hammorui (2003) found out that mathematics teachers were not good problem solvers, especially for transformational problems.

Students must be motivated by the teacher, because NCTM (1998) says that students are not able to be successful problem solvers without teacher’s help. A teacher has to guide his

students to do problem solving activities. But Krulik & Rudnick (1987) suggested that the students must attend the problem solving process. They advised using interesting problems for the students to encourage them to solve the problems. To help or guide the students is not to do all the process for them. It should be remembered that problem solving is a process and students should know this process and do it by them.

Bourne and Dominowski (1994) analyzed Dewey's problem solving steps. There were five steps of Dewey for problem solving according to the study:

1. Understanding the difficulty of the problem
2. Location and definition of the problem
3. Formulation of alternative solutions
4. Choosing the most appropriate way to find the solution
5. Testing the possibility of the solution that was chosen

Bourne and Dominowski mentioned that Dewey was not interested in the result. He was curious about whether the way of the solution was useful for the problem.

Although there were many research on problem solving steps, there were some differences between the steps that were used (Polya, 1973, Schoenfeld,1983, Garofalo&Lester, 1985). Armour-Thomas and Artzt (1992) studied on heuristics of Polya, Schoenfeld and Garofalo and Lester. After analyzing these heuristics, they decide to use a heuristic which has many steps inside. They suggested using as many Problem Solving Methods as possible for novice problem solvers.

The number of the steps changes in each study, but the point of the origin was the study of Polya (1973). Polya stated the problem solving steps in his famous book "How to Solve it" and he was determined mathematical discovery on understanding, learning, and teaching problem solving in each press of his book.

Polya (1973) in his famous book “How to Solve It” states that the best way to help a student when solving a problem is to ask him the same questions like “What is unknown?” or “Could you restate the problem?”. They were then generalized by Polya and were defined as the four phases of problem solving.

1. *Understanding the problem*: This is restating the problem, on which we decide the unknown, given data or considering the condition. Polya states that it is meaningless to try to solve a problem without understanding it.

2. *Making a plan*: This phase is recollecting the previously learned knowledge and deciding on which calculations computations will be used.

3. *Carrying out the plan*: This step is implementing the plan formerly devised. The plan is a general outline, therefore, in this step; the details of the problem have to be examined carefully.

4. *Looking back and extend*: This is reconsidering the result and the path that led to it in order to consolidate the knowledge and generalize it to develop an ability to solve problems.

However Polya (1973) mentioned looking back and extend, this study did not cover this step of problem solving to avoid injustice between experimental and control group of the study. Looking back and extend step was included by the experimental groups lesson plans. Looking back step was used as controlling step, and students controlled their results arithmetically and logically for this step. Extension part of the step was done as a brain storming activity after each problem in experimental group. Extension was very different from problem posing. While doing extension, students tried to redesign the problem they had just been solved.

Other than problem solving steps, there are 11 strategies to solve a problem. Problem Solving strategies are listed below.

1. *Working backwards*: This strategy is solving a problem from the last step to the beginning(Krulik & Rudnick, 1987).

Example problem related to the strategy:

"Candis has an 11-liter can and a 5-liter can. How can she measure out exactly 7 liters of water?" (Krulik & Posamentier, 1998, p.20)

2. *Finding a pattern*: This strategy requires analyzing the given numbers or knowledge and looking for a pattern of them (Krulik & Rudnick, 1987).

Example problem related to the strategy:

"In a room with 10 people, everyone shakes hands with everybody else exactly once. How many hand-shakes are there?" (Krulik & Posamentier, 1998, p.10)

3. *Adopting a different point of view*: This strategy is about the problems which cannot be solved by the way that be seen easily (Krulik & Rudnick, 1987).

Example problem related to the strategy:

"Find the value of (x+y) if, 123x+321y=345 , 321x+123y=543 ." (Krulik & Posamentier, 1998, p.81)

4. *Solving a simpler, analogous problem*: This strategy requires finding solution with the solution of a similar but simpler problem (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*Given 19 consecutive integers that sum to 95, what is the 10^{th} of these numbers." (Krulik & Posamentier, 1998, p.111)

5. *Considering extreme cases*: This strategy is about checking out the extreme values of given problem(Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*Find the missing digits in the seven-digit number 1,2_ _ , _ _ 6 so that the number itself is equal to the product of three consecutive numbers. What are those three numbers?" (Krulik & Posamentier, 1998, p.129)

6. *Making a drawing*: This strategy requires using charts, schemes, tables, illustrations etc. to solve the problem (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*Among 40 Girl Scouts in one division at Camp Ellwood,14 fell into the lake, 13 came down with poison ivy, and 16 were lost on the orientation hike. Three of these had poison ivy and fell into the lake. Five of them fell into the lake and got lost. Two of them experienced all three mishaps. How many of the Girl Scouts in this division escaped with none of these mishaps?" (Krulik & Posamentier, 1998, p.141)

7. *Intelligent guessing and testing*:This strategy requires guessing the solution or the exact value that is asked in the problem and testing that if it is correct or not (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*Two positive integers differ by 5. If their square roots are added, the sum is also 5. What are the two integers?" (Krulik & Posamentier, 1998, p.183)

8. *Accounting for all possibilities*: This strategy is about scanning all the possibilities of the problem situation (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*A digit is inserted between the digits of a two-digit perfect square number, to form another perfect square. Find the three-digit squares formed in this way." (Krulik & Posamentier, 1998, p.201)

9. *Organizing data*: This strategy requires to organize all the given values or knowledge to solve the problem (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*Find the value of the expression 20-19+18-17+16-15+14-13+12-11" (Krulik & Posamentier, 1998, p.221)

10. *Logical reasoning*: This strategy requires analyzing the relation of the given values or knowledge and asked ones in the problem (Krulik & Rudnick, 1987).

Example problem related to the strategy:

*"*When a certain integer is divided by 15, the reminder is 7. Find the sum of the reminders if we divide the same integer by 3 and then by 5." (Krulik & Posamentier, 1998, p.231)

11. *Deriving an equation for the problem*: This strategy requires using the suitable equation to find the solution for the problem (MoNE, 2005).

Example problem related to the strategy:

"Two children were taking their tropical fish to a school pet show. Emily said to Sarah, "Give me one of your fish and I'll have exactly as many as you have." They walked a little bit further and Sarah said to Emily, "Give me one of your fish and I'll have twice as many as you have." How many fish does each child have?" (Krulik & Posamentier, 1998, p.177)

2.1.3 Problem Solving Method

If a student knows the way to solve a problem, he could use this way any time. Snelbecker (1974) told that learning the heuristics and working strategies for making future discoveries are some advantages of discovery method. It is learned to be successful. It could be said as a benefit of Snelbecker's words, solving a problem makes a person happy, confident and smart. Problem solving has its own power to make a person feel smart and confident.

Success must be earned with one's own effort not just "given" (Krulik & Rudnick, 1987). Knowing problem solving procedure increases the possibility to solve any problem. This supports self confidence. Students think that solving a challenging problem is more interesting than the one that is routine (Posamentier & Stepelma, 2002). Every person wants to be smart. If a person knows how to solve a problem, he thinks he is smart. This is the way to have the ability to solve real life problems also (TD, 1974).

The teachers' goals could be

1. Develop abilities to think and solve problems

2. Develop abilities to connect and integrate experience (Polya, 1973).

"Problem solving can be the vehicle used to introduce our students to the beauty that is inherent in mathematics, but it can also be the unifying tread that ties their mathematics

experiences together into a meaningful whole. One immediate goal is to have our students become familiar with numerous problem solving strategies and to practice using them" (Krulik & Posamentier, 1978, p.2) .

To make students familiar with problem solving, while teaching problem solving, the teacher should first present organized series of steps to follow to the students (North, 1992). This should be in a well organized plan. In their book, Krulik and Rudnick (1987) advised the instructors to begin teaching problem solving process with relatively simple problems so as to ensure reasonable degree of success.

It was thought that, students have to attend the instruction. If a student refuses to even attempt to solve a problem, there can be no problem solving activity. It is mentioned in the same book of Krulik and Rudnick (1987). Hence the teacher has to make his activities enjoyable and real life-related. As mentioned earlier, if students think that the activity is interesting, they attend the problem solving process naturally.

Students should solve as many problems as they could, by themselves. Thus, according to NCTM (1991), real problem solving procedures are not learned and are not conducted. That means students could not know the solution of a problem. If they could know the way, there is not any "problem". Students should know how to solve a problem not just finding the solution. Knowing how to solve a problem is ability to use problem solving steps and strategies in an appropriate situation. In NCTM Standards 2000, it is mentioned that all students should be enable to apply and adopt a variety of appropriate strategies to solve problems (NCTM, 2000). Holton (1994) gave an advice to the teacher to let the students learn various techniques of problem solving. In this way, he mentioned, students could use the techniques by themselves. This statement shows that students should know all the process of

the problem solving, where this process includes four steps of Polya (1973), mentioned for problem solving, and problem solving strategies well.

Teaching problem solving is one of the important objectives of mathematics education at any level of the secondary grades (Özkaya, 2002). In fact, in mathematics curriculum, both in Turkey and other countries, there are objectives about problem solving (NCTM, 1989; TD, 1974). In Turkish elementary school mathematics curriculum it is mentioned that students use problem solving strategies when they are solving mathematical problems as one of the Turkish national education objectives (MoNE, 2005). In high school mathematics curriculum problem solving is an important situation also. There are problem solving strategies mentioned Turkish high school mathematics curriculum more detailed than elementary and middle school mathematics curriculum does (MoNE, 2005).

On the other hand, Olowa (2009) compared problem solving approach with subject matter approach in science education in secondary school. This study shows that Problem Solving Method is more effective than subject matter. In this condition, Olowa recommends that Problem Solving Method should be used by larger amount of teachers.

Yavuz (2006) studied the effect of Problem Solving Method on 9^{th} grade students' affective domains and mathematics achievement. He found that using the Problem Solving Method changed the students' attitudes toward mathematics in Anatolian high schools. Although there was a difference between students' mathematics attitudes, there was not any change in students' mathematics achievement.

Besides, Kertil (2008) searched the teachers' ability on mathematical problem solving. He found out that teachers were not capable to integrate their mathematical knowledge into the real life situations/problems. The study was different from other studies the reason was not only the participants also the problems that were used in the study. There were used real life

problems and some of them had no specific answer. Kertil could increase the teachers' mathematics problem solving abilities; even the difference was very low. He expressed that only three-week mathematics modeling made that difference. He also mentioned that the teachers should be trained with Problem Solving Method to be qualified teachers. It could be helpful to remind the idea of Polya (1973) about teachers. He thinks that if a teacher could not have the ability to do what he teaches, he could not be successful in teaching it.

Moreover Kandemir (2006) examined that there was a strong correlation between ability to problem solving and bias or attitudes toward problem solving. He studied with prospective mathematics teachers and found out that learning creativity techniques increased the prospective teachers' abilities on problem solving. Creativity techniques motivated the participants, as a result, their attitude toward problem solving increased too.

7^{th} grade students' Problem Solving Performance was studied by Koç (1998). He stated affect of Problem Solving Method in the achievement of different steps of Polya's for problem solving. He found out that teaching by Problem Solving Method has positive effect regarding the Traditional Method under making a plan and carrying out the plan step. Different from Koç, 10^{th} grade students' Problem Solving Performance and attitudes toward Geometry was studied by Özkaya (2002). That study showed that 10th grade students' Geometry achievement and attitudes toward geometry has increased who were taught by Problem Solving Method.

Another way to improve problem solving skills is "problem posing" which means constructing a new problem (English, 1997; Lavy & Bershadsky, 2003). Dickerson (1999) found out that middle school students liked problem posing and problem posing helped them to increase their mathematics success. Dickerson thinks that problem posing is a supportive activity to the mathematical knowledge; however some teachers thought that it took too much

time. But Owens (1999) claimed that problem posing was a serious process and it could not be expected to increase mathematics achievement and attitude toward mathematics in a short term. On the other hand Grundmeier (2003) found out that prospective teachers wanted but also needed to be problem posers. Problem posing is one of the important parts of mathematics education, but it is a wide method. In the present study, according to the results of the studies, 4th step of Polya's problem solving steps was included the extension, which was a part of problem posing. This study does not include problem posing, because of its nature. Problem posing is not a part of problem solving in order that searching problem posing in this short-term study could not be appropriate.

2.3 Attitudes Toward Mathematical Problem Solving

"Children who enjoy solving problems and feel satisfaction or pleasure at conquering a perplexing problem are much more likely to persevere, make second and third attempts, and even search out new problems. Negatively attitudes have just the opposite effect" (Van de Walle, 2007, p.58). It could be seen the importance of the attitude from these words. Analyzing the place of attitude in literature can be useful. There are some resources on attitude toward Mathematics and Problem Solving shown below.

Resources showed that there is a strong relationship between students' success in mathematics and the students' attitudes toward mathematics (Akman, 2005; Hanley, 1995; Kandemir, 2006; Koç, 1998; Mayo, 1994; McLoad, 1989; Özkaya, 2002). Although the samples of the studies changed, the results were the similar way. Nevertheless there are studies which opposed the correlation between the success and the attitude toward mathematics (eg.Yavuz, 2006; Yılmaz, 2007) .

Many mathematics teachers take seminars, extra courses, work-shops to learn how to increase the students' success. Teachers tend to teach mathematics to their students

effectively (Kayan, 2007). Belief of ability to do is related with the ability to do (Mayo, 1994). There is a strong relation between attitude and success in mathematical problem solving (McLoad, 1989).

As mentioned above, teachers should increase the students' attitude toward mathematics to increase their success. Teachers observe their classes and practice good and bad situations while the teaching-learning process is running. The whole search focuses on one base, how to encourage the students to learn mathematics by. It is needed to affirming and supporting full participation and continuous study of mathematics by all students. NCTM Standards (NCTM, 2000) show that an instructor should plan the process of teaching mathematics by supporting the lesson with use of variety of tools like computers, calculators, pictures and pictorial models, manipulatives, etc and be creative to make environments to encourage students and teacher during the process of mathematics teaching-learning.

Blount and Klausmeier (1968) said that in their book Teaching in Secondary School, under the subtitle Using audio-visual materials that visuals are important to make the lesson interesting. They expressed that using interesting and challenging materials, starting lesson with relatively easy activities to make activities interesting for the students, under the subtitle Improving Work and Study Methods.

Yıldız (2008) interpreted new high school Mathematics curriculum which has been carried out since 2005 as it supports different teaching methods in high school. According to him, using different teaching methods increases the students' attitude toward mathematics.

Akman (2005) mentioned that attitude toward mathematics and mathematics success has a positive correlation. Özkaya (2002) also found a significant correlation between problem solving and attitude toward problem solving.

Charles et al.(1987) identified the reasons for teaching problem solving in a detailed way. According to them, the goals of teaching problem solving are:

1. To develop students' thinking skills

2. To develop students' abilities to select and use problem solving strategies.

3. To develop helpful attitudes and beliefs about problem solving

4. To develop students' abilities to use related knowledge.

5. To develop students' abilities to monitor and evaluate their thinking and progress while solving problems.

6. To develop students' abilities in cooperative learning situations.

7. To develop students' abilities to find correct answers to a variety of types of problems

But in real life, mathematics is not learned that way. Mathematics teachers usually teach as they learned: because their experience of learning mathematics has a powerful effect on their choice of own teaching style (Özkaya, 2002). She also pointed that students tend to use the problem solving strategy which they learned before, in class or somewhere else. As a result, students have to be encouraged to do problem solving by their teacher.

Rips (1994) studied on psychological basis of problem solving. There was a conclusion that Rips admitted that everybody cannot learn problem solving. Rips advices that the instructors to spend their time to motivate their students (novice problem solvers) to learn problem solving, because most of the people need high motivation to solve problems.

In Thailand, Nuangchalerm et al (2009) searched the factors which affect the problem solving abilities of 6^{th} grade students. They observed that teachers' behaviors, students' self efficacy,

and students' attitudes have significant effect on students' problem solving ability. Students' problem solving achievement mostly depends on their, and even their teachers' attitudes toward the problem solving.

As a summary, there are studies on mathematics achievement, problem solving performance, attitudes and beliefs on mathematics and/or problem solving. Some studies expressed different teaching methods were useful in mathematics education; some are expressed Problem Solving Method in detail. Problem Solving Method had different effects on different kinds of participants, and under different titles of mathematics. In general, studies showed that, teachers' beliefs on problem solving were positive. Some of the studies mentioned that teachers took an important role in education. That means, if teachers tend to use a teaching method, that method causes the mathematics success. In this study Problem Solving Method was searched. The students' improvement in problem solving performance observed according to the treatment which is based on problem solving. Attitudes toward mathematics and problem solving were other important parts of the present study. The change on attitudes towards mathematics and problem solving searched before and after the treatment.

CHAPTER 3

METHODOLOGY

In this chapter, research design of the study, main and sub-problems, hypotheses, variables, population and sampling, measuring instruments, procedure, analysis of data, and assumptions and limitations parts are included.

3.1 Research Design of the Study

The purpose of the study was to investigate the effect of Problem Solving Method on 9th grade students' problem solving performance on Functions, attitudes toward mathematics and problem solving. In this study a pre-test - post-test control group design (Fraenkel & Wallen,1996) was used as outlined in Table 3.1.

Table 3. 1.1. Research design of the study

Group	Pre-tests	Treatment	Post tests
EG	PT PSAS MAS PSPT	PSM	PSAS MAS PSPT PSPO
CG	PT PSAS MAS PSPT	TM	PSAS MAS PSPT

In Table 3.1, the abbreviations have the following meaning: EG represents Experimental Group, which received instruction with the "Problem Solving Method" (PSM); CG represents the Control Group, which received instruction with the "Traditional Method" (TM).

The measuring instruments in Table 3.1 are the following. The Placement Test (PT), Problem Solving Attitude Scale (PSAS), Mathematics Attitude Scale (MAS) and Problem Solving Performance Test (PSPT) were administered as pre-tests and as post-tests. Problem Solving Performance Observation (PSPO) was applied during the study.

During the study five different measuring instruments were administered. At the beginning of the study PSPT, ATPS and MAS were used to measure the equivalence of the treatment groups with respect to problem solving and attitudes toward problem solving and mathematics. These three tests and scales were applied again at the end of the study. Experimental group students took PSPO to identify the students' thinking process while they were solving the problems.

3.2 Variables

The dependent variables of the study can be considered as

- Students' scores in Placement Test
- Students' gained scores in Problem Solving Performance Test considering "understanding the problem" step
- Students' gained scores in Problem Solving Performance Test considering "making a plan" step
- Students' gained scores in Problem Solving Performance Test considering "carrying out the plan" step
- Students' gained scores in Problem Solving Attitude Scale
- Student's gained scores in Mathematics Attitude Scale

Independent variable of the study is treatment in experimental group and control group.

3.3 Participants of the study

The study was consisted of 9th grade students in a private school in Ankara in 2007-2008 academic year. Subjects were determined by using convenient sampling. There were 67 students. While there were 33 students in experimental group, 34 students were in control group.

3.4 Measuring Instruments

As it was stated at the beginning of this chapter, two different scales and two tests were used for data collection:

- Placement Test (PT)
- Problem Solving Performance Test (PSPT)
- Problem Solving Attitude Scale (PSAS)
- Mathematics Attitude Scale (MAS)

3.4.1 Placement Test

This test was prepared by the mathematics teachers in the high school where the study took place. There were 30 items which were divided as 7 geometry questions, 3 word problems, 1 probability question, 5 algebra questions, 4 arithmetic questions. The test was prepared with respect to secondary school mathematics curriculum and applied to the 9th graders in 2007-2008 academic year, when the number of the students was 67. Placement tests alpha value in the school is .812.

Placement Test was used to deal the students into the classes equally. That means, the directory of the school wanted to make each class's success equal or very close each other. The placement test was prepared by the mathematics department of the high school according

to the primary and secondary school mathematics curriculum and applied to the students at the beginning of the academic year.

3.4.2 Problem Solving Performance Test

This test was designed by the researcher to examine students' ability to do problem solving on "Functions". The test consisted of ten open ended questions (see Appendix A) that could be seen clearly what the students' thinking skills from the answers. The questions were designed as real life situations and motivated the students to solve them. However the items required knowledge of the subject "functions", some of the students tried to solve these problems in their own way.

It was decided to understand the students' problem solving performance when preparing the test. Because of that the test was designed as open ended. These open-ended items gave the chance of understanding the students' decisions, strategies and methods, when they were solving each problem.

The problem solving performance test did focused on the students' use of problem solving steps and strategies it did not include the looking back and extend step of problem solving; because the 9^{th} grade students in 2007-2008 academic year had no idea about problem solving. That was decided that if the test included the looking back and extension step, it would be unfair for the control group students. Experimental group students got used to control/check their solutions after they applied the carrying out the plan step. There were some studies, for example; Posters, work groups,… etc., were done to express the importance the looking back step of the problem solving.

Three items of the test (5^{th} , 9^{th} and 10^{th} items) were adopted from the book The Language of Functions and Graphs (Swan, 1985). These items were adapted to 9th grade curriculum. All

the problems which are designed by the researcher were used last five years to the 9th graders. It could be said that these problems had been tested before the study.

Problem Solving Performance Test was developed by the researcher; the reliability study was accomplished in SPSS for each item separately after pilot study is done. All the items in the test were checked by two of the 11th grade students of the researcher and two of her colleagues. Rubric of PSPT (see Appendix B) was prepared by the researcher also. The maximum scores of understanding, making a plan and carrying out a plan were 60, 60 and 105 respectively

There are some examples of the items of PSPT:

Item1: Difference of a plant's length is defined with the given statements:

a) At the beginning, length of the plant was 15cm.

b) This plant grows 7cm each year.

According to these statements, find the length of the plant 25 years after planting it.

Explain your answer with your mathematical knowledge.

Item 3: Beril walks to school in 30 minutes, runs to school in 15 minutes. If the distance of the Beril's house and school is 450m, find the walking velocity of Beril.

Item 10: A factory cafeteria contains a vending machine which sells drinks.

On a typical day:

- *The machine starts half-full.*
- *No drinks are sold before 9am or after 5pm.*

• *Drinks are sold at a slow rate throughout the day, except during the morning and lunch breaks (10.30-11 am and 1-2 pm) when there is greater demand.*

• *The machine is filled up just before the lunch break. (It takes about 10 minutes to fill).*

• *Sketch a graph to show how the number of drinks in the machine might vary from 8am to 6pm.*

The content validity of the test was examined by the mathematics teacher and expert. Inter-rater reliability study was done with 54 students of the pilot study. The answers were read by researcher and one of her colleagues by using the rubric which was prepared by the researcher. Correlations between these two teachers' marks for each question and steps of the questions' problem solving steps were analyzed. Inter-rater reliability for each stage was calculated by using Pearson-product moment correlation coefficient. Correlation of researcher's marks and her colleague's marks of total scores was .919. On the other hand it was important to analyze the correlations between these two teachers' marks with respect to problem solving steps. Correlation of researcher's marks and her colleague's marks of total scores in understanding step was .875, making a plan step was .884, carrying out the plan step was .912.

3.4.3 Problem Solving Attitude Scale

This scale includes 39 items to identify the students' attitudes toward Problem Solving (see Appendix C). This scale was developed by Özkaya (2002). PSAS was designed to collect self-assessment data from students about their performance, attitude, or experience in problem solving. The scale was in Turkish. The items in the scale were formed as 24 positively worded and 15 negatively worded items. The test was a 5-point likert-type scale Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree. Positively worded items

were coded starting from Strongly agree as 5 to Strongly disagree as 1. Negatively worded items were coded as from 1 to 5. The reliability coefficient was found .91 in the pilot study by Özkaya (2002). In the present reliability it was found .951. The range of total scores of The PSAS was 39 and 225.

3.4.4 Mathematics Attitude Scale

Mathematics Attitude Scale (MAS) was developed by Aşkar (1986) (see Appendix D). The scale was in Turkish. It consisted of 10 positively worded and 10 negatively worded items about attitude toward mathematics. They were in 5-point likert-type scale: Strongly agree, agree, undecided, disagree, strongly disagree. Positively worded items were coded starting from Strongly agree as 5 to Strongly disagree as 1. Negatively worded items were coded as from 1 to 5. In Aşkar's (1986) study the results of Principal Component Analysis supported that MAS was one-dimensional. In the same study, its alpha reliability coefficient was found as .96. In the present study its alpha reliability coefficient was found .955. The range of total scores of the MAS is between 20 and 100 in this study.

3.5 Treatment

Treatment started with pilot study in the second semester of 2006-2007 academic year with 9^{th} grade students in a private school in Ankara. After the pilot study, main study took place in the first semester of 2007-2008 academic year with 9^{th} grade students of the same school.

3.5.1 Pilot Study

Pilot study was done in the second period of 2006-2007 academic year with the 9^{th} grade students in the school where the main study would be done. This pilot study changed the way of the main study from the first thought direction. During the pilot study, the researcher taught all 11 Problem Solving Methods and problem solving steps. While the pilot study was being done, the subject was "absolute value", as curriculum refers. Pilot study was done with

example problems for the problem solving instruction sheet which had been prepared by the researcher. After the pilot study, the students' reactions were analyzed and the main study took its shape.

At first, a group of handouts that examined including the problem solving strategies and problem solving steps in a detailed way. These handouts were prepared by the researcher. At the beginning of the handout, the definition of Polya's problem solving steps took place after that there were problem solving strategies with example problems that could be easily solved with the related strategy. Most of the problems in the handout had been translated and adopted from the book Problem Solving Strategies for Efficient and Elegant Solutions (Krulik & Posamentier,1998). After the problems for each strategy, there were several problems on absolute value, the subject of that time of the year. These absolute value problems were designed by the researcher.

While the pilot study was running, it was observed that students who learned the steps of problem solving could easily solve the problems related with absolute value. That result gave the courage to do the main study while a subject, which is known as hard to learn and teach, was being discussed. According to that discussion, the main study was able to be done in several subjects of 9^{th} grade such as "relations" or "functions" in the first period of the academic year or "absolute value" or "word problems" in the second period of the academic year.

When the handouts were studied in the class, the students told their decisions about both the handouts and the pilot study. During the pilot study, most of the students thought that the problems which they studied were useless for them and the process of solving a problem took a long time and strategies of solving problems were too many. These observations helped the researcher make the decision that, in the main study there could have been some real life

problems and other problems could have been chosen subject related and could be solved if problem solving steps and strategies were known well. The pilot study helped the researcher to make decisions about the preparation of the main study. The results of the pilot study are listed below:

• The strategies should be discussed at the beginning of the academic year.

• The problems should be interesting for the 9^{th} grade students.

• The problems should be as realistic as possible.

• Each strategy should be discussed in one or two problems instead of solving two problems for the strategy and two problems for related subject separately.

• The students should be more motivated to use the strategies in the class.

• The students should feel that they need the strategies to solve any problem.

Main study was prepared after the discussion of the pilot study. According to the decisions explained below, main study was decided to be done in the first semester of the year, and "functions" was chosen as the subject of the problems, because functions was one of the most difficult subjects for 9^{th} grade students in every academic year. Handouts, and lesson plans had been prepared at the beginning of the first period of the 2007-2008 academic year. Problem solving strategies were taught one by one and one example problem for related strategy came after, then, function problems related with that strategy took place for each strategy. The students had to use that strategy when they were solving function problems, if it was possible for that strategy and "functions".

3.5.2 Main Study

The study was done in the first semester of 2007-2008 academic year. It took 21 lessons with both experimental and control groups. The subject "functions" was chosen for the study because of the difficulty of the subject for 9th graders and there weren't many ways to teach "functions" properly, this study was a hope for teaching "functions" in an enjoyable way. Every academic year, teachers of the high school where this study was done, feel bad when they think of the students' reactions while they are teaching "functions". Almost no student in 9th grade feels that he is successful in "functions". These decisions came from researchers' informal observations from her colleagues and her six-year school experience as 9th grade Mathematics teacher at a private school, where both pilot and main study were done.

The study was decided to be done in a private school because the researcher teaches mathematics in that school. The time of the study was chosen as the first semester of 2007-2008 academic year because it was decided, after the pilot study, that problem solving steps and strategies had to be given at the beginning of the year. The students of the experimental group were chosen as the students of the researcher.

At the beginning of the school year the students were not known well by either researcher or directory of the school as a result of being new students of a high school. Groups of 9th grade were distributed to the teachers by the directory of the school. Experimental group and control group students were stated according to their classes. It could be said that the sample of the study was convenient.

In every academic year there was an examination to set the stage for making different groups' success equal to each other. According to that examination, all the groups were defined in the school at the beginning of the school year. This exam was called Placement Test (PT). After

PT 9th grade classes were formed. These four classes' means were equal or close to each other in PT.

There were 67 ninth grade students in the school in 2007-2008 academic year. Although there were four 9th grade groups in the school, these four groups were divided into two. Two groups were experimental group and other two groups were control group. Before the main study started, the students in both experimental group and control group were informed that they were in a research. So if they did not want to be in the research they should have said at the beginning. Every student approved to be in this study. The experimental group was taught by the researcher. Control group was taught by two other mathematics teachers of the school. Control group consisted of two different classes each was being taught by their own mathematics teacher. Some random lessons were recorded by video camera, four lesson from the control group and four lessons from the experimental group, on the same subject, and these videos were watched by all five teachers of the mathematics department of the school where the study was done. It was important to record the same subject from both experimental and control group. So recording times were chosen carefully, there were same subjects that were taught both experimental and control group. The mathematics teachers who watched the videos used an observation form (in Appendix G) to determine whether Problem Solving Method used in experimental group and Traditional Method in control group or not.

This procedure was done to help the researcher to control whether the methods given to experimental group and control group were different from each other, experimental group should have been taught by Problem Solving Method and control group should have been taught by Traditional Method. These videos were watched by five mathematics teachers. The researcher asked their opinion about the teaching methods which were used (either

Traditional Method or the Problem Solving Method) in the control group and the experimental group. After watching these videos these teachers made the decision that Problem Solving Method was used only in the experimental group.

The observation form (see Appendix G for the original form) was used to clarify whether there were used Problem Solving Method or not. Teachers filled different forms for different lessons. There are questions and teachers' distribution of answers for experimental group and control group in Table 3.5.2. Number of the answers the teachers gave for each group is shown in the table. Teachers filled out the form as a check list. Every lesson was watched in the mathematics department and every item was discussed for each lesson. It is very important to express that, every mathematics teacher in the department was mostly in concurrence with each other. When their answers were not parallel, they determined the answer what they should give. After taking all the answers, researcher added all the answers up and wrote the number of checks. Table 3.5.2 was constructed as written above. As an example, for 9^{th} item "teacher told the relationship between real life and subject" there were 2 'yes' and 2 'no' answers for control group and 3 'yes' and 1 'no' for experimental group. That means, control group teacher told the relationship between real life and subject in 2 of the control group lessons.

Table 3.5.2.1 The distribution of the mathematics teachers' answers to the observation form

	Control Group		Experimental Group	
Questions	Yes	No	Yes	No
1. Teacher used warm up at the beginning of the lesson.	3	1	3	1
2. Teacher gave opportunity to the students in the lesson.	3	1	4	0
3. Problems were used in the lesson.	1	3	4	0
4. Problem solving steps were used while solving the problems.	0	4	4	0
5. Students were encouraged to use problem solving steps when they were solving problems.	0	4	4	0
6. Students were encouraged to use problem solving strategies while they were solving problems.	0	4	4	0
7. Students' decisions were sized up.	3	1	4	0
8. Teacher used real life examples for the subject.	2	2	3	1
9. Teacher told the relationship between real life and subject.	2	2	3	1
10. Teacher made the problems which were used in the lesson interesting for the students.	3	1	3	1
11. Teacher emphasized which of the questions were problem, which were not	0	4	4	0
12. Teacher paid attention to almost every student in the class.	4	0	4	0
13. Teacher summarized the lesson at the end.	4	0	3	1

However, lesson plans have usually been prepared by all the teachers who teach the same level in that school, as an exception, there were no connections between experimental and control group teachers, by the time of the experiment. These teachers were under control by

the end of every week to check if they were in the same part of the subject, or close to each other by the head of the mathematics department. Hence experimental group and control group were taught functions in the same subject order.

Experimental group was taught "functions" by special organized lesson plans that require all 11 strategies and 4 steps of Problem Solving. There is a part of the hand-outs of the experimental group in Appendix E. As it could be seen on Appendix E, experimental group learns the subject theoretically after that, problems took place. Students in experimental group finds the rules which are learned before the control group solve any problems or exercises. Experimental group's lesson plans included same function problems with the control group's lesson plans. Although function problems were at the beginning of the new section in experimental group's lesson plans, they were after the similar exercises in the control group's lesson plans. In other words, experimental group used function problems as understand and apply Problem Solving Method but control group used them as exercises of functions. The experimental group students solved the problem at the beginning of the instruction, after learning the subject theoretically. On the other hand control group students solved these problems after learning the solving process with drilling exercises. Furthermore in the experimental group self observation form was used, three times, for students' awareness to problem solving (see Appendix F). Self observation forms were used in the experimental group after 5^{th} , 12^{th} , and 25^{th} problems in the lesson. The students' answers showed that students got used to use Problem Solving Method after a number of problems.

The researcher designed four different flash cards to take the students' attention to four steps of Polya's Problem Solving. These materials are shown on Figure 3.5.1.

Figure 3.5.2.1 Flash cards which were used as symbols of steps of problem solving

Red symbol A (A:Anlama) was defined as understanding the problem.

Yellow symbol P (P:Planlama) was defined as planning the solution.

Green symbol U (U:Uygulama) was defined as carrying out the plan.

Blue symbol K (K:Kontrol) was defined as controlling the solution.

In Figure 3.5.2. it could be easily seen that these flash cards were used to take the students' attention to the problem solving steps. Every problem was solved with the help of these flash cards and written on the white board one by one. This method motivated the students to attend the problem solving process.

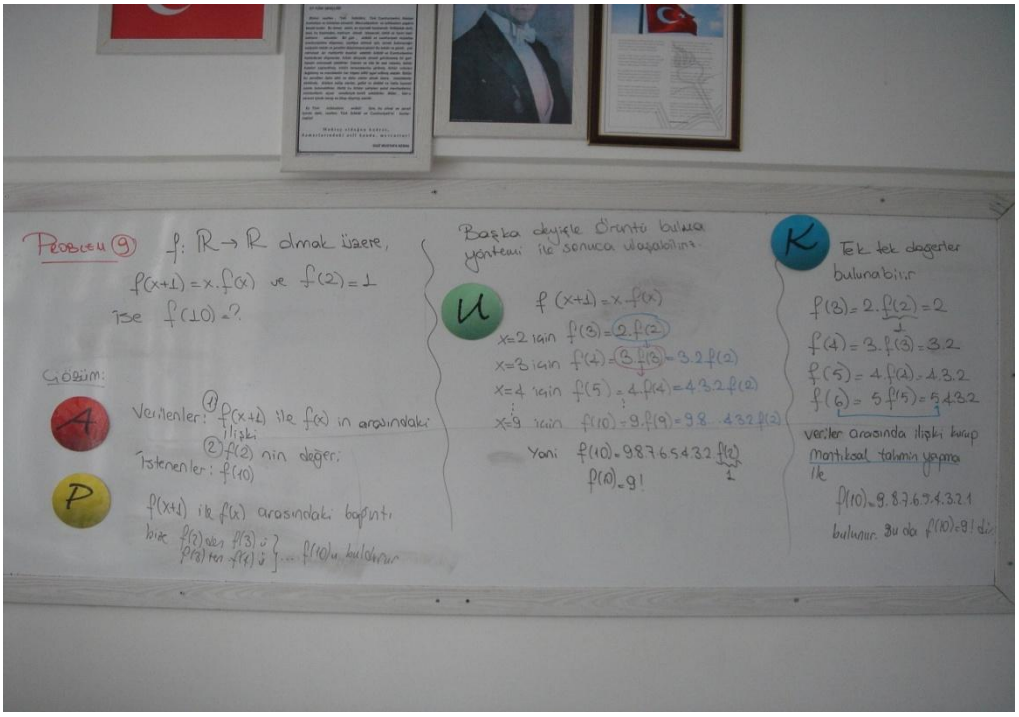


Figure 3.5.2.2 General view of the usage of the flash cards

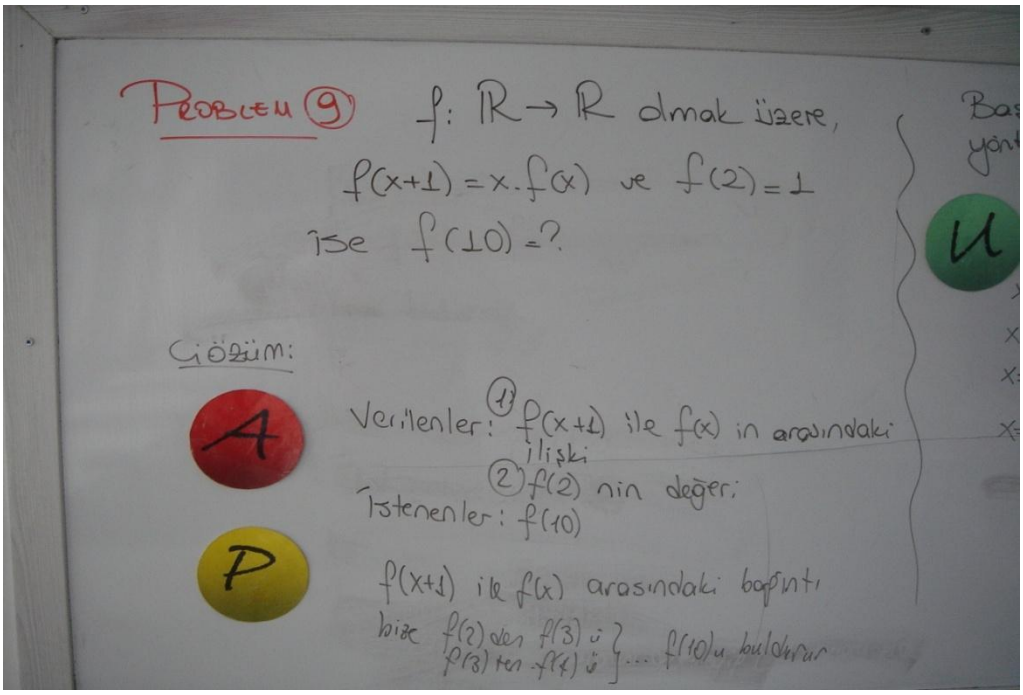


Figure 3.5.2.3. Understanding and making a plan steps are in use

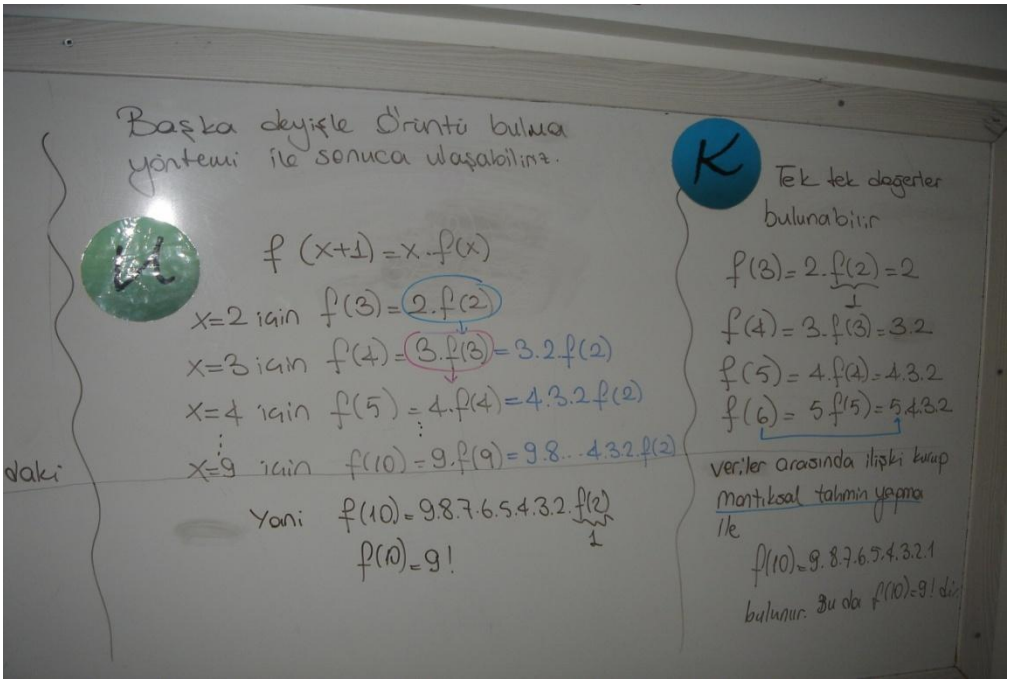


Figure 3.5.2.4. Carrying out the plan and looking back and extend steps are in use

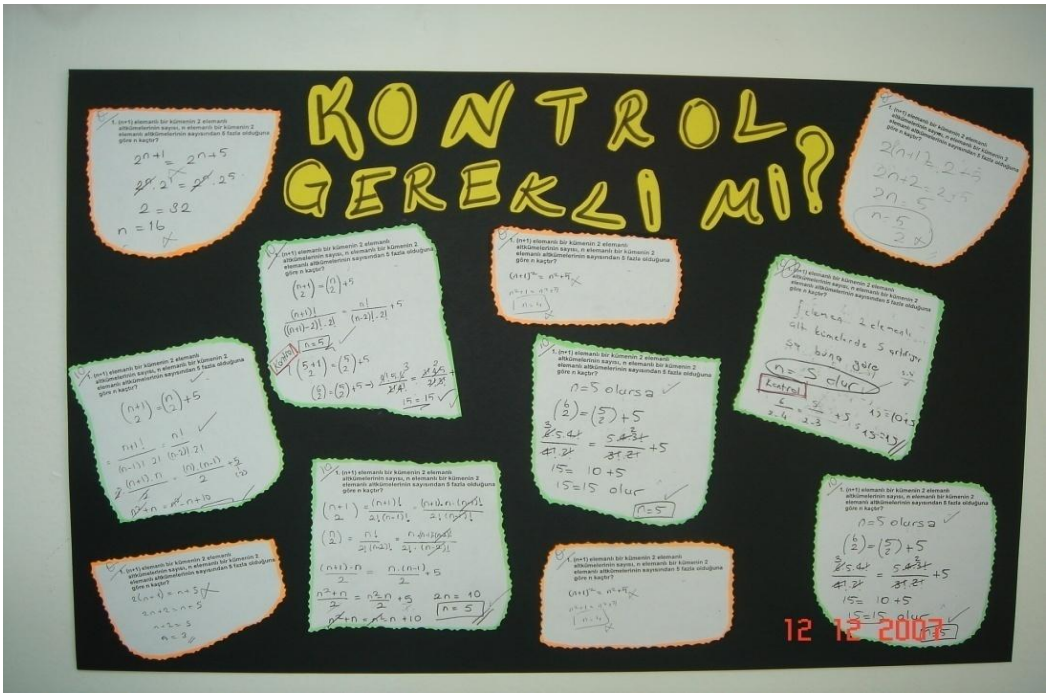


Figure 3.5.2.5. Poster to express the importance of looking back and extension step

Experimental group instructor used these materials to take students' attention while they were solving problems. Instructor motivated the group to solve the problems step by step. Students did each step of problem solving one by one on the board while others were sitting in their desks and solving the problem and ready to give the advice to their classmates. There are examples in Figure 3.5.2, Figure 3.5.3, and Figure 3.5.4. to show how did the experimental group use the materials which the researcher designed.

Experimental group made a poster to analyze how important the looking back step was. This poster was formed by the students' answers to the problems in mini exams. Some of the students controlled their solution and some of them did not. Number of the students who controlled the solution was smaller than the number of the students who did not. Every student who controlled the solution was successful on that problem, however the students who has solved the problem in a wrong way or found a meaningless result were in the group which included by the students who did not controlled the solution. After this poster study, the students understood the importance of controlling the solution, in other words Polya's looking back and extension step.

Every problem solving strategy was taught with two problems, one of them was used in pilot study and the other one was based on "functions". Every subject in functions started with a new problem and after the students solved that problem, the subject was explained and drilled with examples. This study encouraged the students to solve new problems. In this study there were 36 problems and 11 of them were used to determine 11 strategies of Problem Solving, others were problems of different subtitles of "functions". Students were encouraged to solve each new problem by themselves, when needed; they solved the problems with the help of their classmates. The researcher helped the students to solve the problems when they couldn't find any way to get closer to the solution of the problem.

In every lesson, there was a well planned lesson plan used to state both Problem Solving Methods and teaching functions at the same time (see Appendix E); as discussed after pilot study. At the beginning of the study experimental group students refused to use problem solving steps and strategies, nevertheless they started to solve problems step by step after two weeks. At the end of the study students of experimental group were using Problem Solving Method. These statements were observed according to the researcher's diary which was written while the study was running. Some parts of the diary showed the increase of the students' behavior and attitude toward the problem solving.

E.g. November.26th.2007 *"It was observed that students' attitude toward problem solving was negative. They hated the Polya's problem solving steps, especially looking back and extend step. They thought that the 4th step of problem solving was useless and using it is just wasting time."*

November.28th.2007 *"Students thought that writing understanding step was wasting time. They mentioned that they were using their mind to do the understanding step. It was still one of the important parts of the lessons to mention the importance of the looking back and extend step."*

December.6th.2007 *"The students wrote the expression f(2x) in terms of f(x) by themselves. It was a shock for me. I haven't seen any student defined a function in terms of another function!"*

December.26th.2007 *"The students defined the inverse function with the help of the given function. They asked no question while they were finding the inverse function of polynomial type function. They needed a minor clue to find the inverse of rational expression."*

December.28th.2007 *"The students found out the graph of inverse function with the help of the graph of the function."*

December.31st.2007 *"The students defined the function g(x) when f(x) and (gof)(x) were given. They used the strategy, solving a simpler analogous problem."*

In other words, they solved problems step by step and they used problem solving strategies automatically, when they saw a problem or a different kind of question. However students' reactions were not that way at the beginning, they started to solve problems step by step. Besides they started to use problem solving strategies automatically, when they saw a different kind of question or a problem. The students in experimental group also understood that problem solving is a serious process in mathematics. The experimental group students looked like they did not accept the new method, but when they were observed while they were solving a problem, it is understood that these reactions were specific adolescence reactions to new things. Because in the examination, it was seen that they were using problem solving steps and strategies even they did not name any specific problem solving strategies at the time of solving the problem but the methods they used were the combination of two or more strategies. That was observed in the functions examination by control group's mathematics teachers. Experimental group students solved the problems in the examination step by step and they controlled their answers after finding the solution. This kind of change was predicted at the beginning of the main study. That is why; looking back and extend (it was called control step in the main study) step was ignored for the performance test. Experimental group was going to be tended to control their solutions different from control group. After the studies to take attention on looking back and extend step, the students' habit were changed in problem solving. The experimental group students wanted to see whether their solution is right or wrong, by controlling their solution.

3.6 Procedure

The present study started with a review of literature about problem solving strategies and Problem Solving Method. Then data collection instruments were developed. Problem solving strategies were stated and eliminated/added for the Problem Solving Method. Problem Solving Method and tests were piloted with 9th grade students in second semester of 2006-2007 academic year in the private school. According to the results of the pilot study, the Problem Solving Method was revised and it was decided to expand the strategies to the lesson plans instead of teaching all the strategies and the steps of problem solving separately.

Sample was stated as all 9th grade students in the private school where there were 67 9^{th} grade students. There were 33 students who were taught by researcher and 34 were in other classes. The experimental group was taught functions with Problem Solving Method and other group was taught functions with Traditional Method. Both experimental and control groups took Problem Solving Performance test, Attitude Toward Problem Solving Scale and Attitude Toward Mathematics Scale as pre-test before the instruction and as post-test after the instruction which it took seven weeks because of the difficulty of the subject functions for 9th graders and the school atmosphere, general examinations, some occasions, etc.

Each PSPT took one class hour and two Attitude Scales took one class hour. All necessary instructions were read before administering the scales in order to neutralize the students' decisions toward the problem solving in the test.

3.7 Analysis of Data

Hypotheses of the present study were tested by using independent samples t-test. The probability of doing type I error, was set to be .05. For the reliability of the PSPT, PSAS and MAS and Cronbach Alpha Coefficients were determined. In the data analysis Statistical Packages for the Social Sciences (SPSS) was used.

3.8 Assumptions and Limitations

The following are the assumptions of the study:

• It is assumed that the participants answer the scales and test sincerely.

• It is assumed that all the tests are administered under standard conditions.

• It is assumed that the experimental group and control group students did not interact much that experimental group did not share their knowledge about the Problem Solving Method.

• It is assumed that the experimental group students did not show their Mathematics lesson notes to their friends in control group.

Limitations are stated below:

• The study was limited to 9th grade students of a private high school in Ankara.

• The study was limited with 67 students.

• The study was limited to the functions unit.

• In the school where the study was done there were some group work for English lesson so that the students were in interaction with the students from other classes. There could not be isolated class atmosphere for both control group and experimental group different from it was thought before.

• In 2007-2008 academic year 9th graders had no idea about problem solving process and what the “problem” is. It was very difficult to explain what the problem solving is.

CHAPTER 4

RESULTS

In this chapter there are the results of the study. These results include statistical evidence for the claims of the study. There are three sections of this chapter, descriptive, inferential statistics and conclusions of the study.

4.1 Descriptive Statistics

There are means, standard deviations, maximum and minimum values of pre-test and post-test of PSPT, PSAS, and MAS. The results were given in the following tables. Table 4.1.1 gives the some descriptive statistics of Placement Test scores.

Table 4.1.1. Descriptive Statistics for Placement Test

Groups	Statistics	Placement Test
CG	Mean	7.47
	SD	4.378
	Minimum	0
	Maximum	19
	N	34
EG	Mean	9.33
	SD	4.143
	Minimum	0
	Maximum	17
	N	33

Table 4.1.1 shows that mean of control group is different from the mean of experimental group in placement test, however standard deviations, maximum and minimum scores are close. At the beginning of the year all 9^{th} grade students who were the members of sample of the study took placement test to define their classes in the school. The results were examined

by measuring and assessing department of the school. This test was used to show the homogeneity of the experimental group and control group. As seen on Table 4.1.1 experimental group students were more successful at the beginning of the year.

Another test was PSPT. The results of its descriptive statistics were given in Table 41.2.

Table 4.1.2. Descriptive statistics of PSPT according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	44.32	70.68
	SD	18.386	27.145
	Minimum	0	18
	Maximum	75	127
	N	34	34
EG	Mean	56.58	86.64
	SD	22.301	31.797
	Minimum	15	27
	Maximum	113	146
	N	33	33

As seen on Table 4.1.2 there are mean differences between experimental group and control group in both pre-test and post-test of PSPT in total scores. Experimental group were more successful than control group at the beginning of the study like in placement test. As it could be seen on Table 4.2 experimental group was more successful both before and after the treatment.

Table 4.1.3. Descriptive statistics of PSPT under the understanding step according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	15.91	24.06
	SD	6.142	7.718
	Minimum	0	5
	Maximum	28	38
	N	34	34
EG	Mean	20.30	27.52
	SD	7.252	8.167
	Minimum	7	8
	Maximum	36	40
	N	33	33

From Table 4.1.3 it is seen that mean difference in pre-test is close to the mean difference in post-test. At the beginning of the study, experimental group was more successful than control group. Moreover at the end of the study, experimental group was still more successful than control group. But when we look at the differences between scores, change in experimental group is smaller than that of control group.

Table 4.1.4. Descriptive statistics of PSPT under making a plan step according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	11.74	19.38
	SD	4.938	7.455
	Minimum	0	5
	Maximum	21	34
	N	34	34
EG	Mean	15.18	24.09
	SD	6.626	8.808
	Minimum	2	8
	Maximum	32	40
	N	33	33

As seen on the Table 4.1.4 differences between pre-test and post-test in experimental group are higher than the ones in control group. Experimental groups mean was higher than control group in making a plan step. After the treatment experimental group was more successful than control group again.

It is important to mention that, there was a difference between changes of the scores under making a plan step, but it was not high enough. In other words, there was a small difference between the control group and experimental group students, however these differences were not statistically significant.

Table 4.1.5. Descriptive statistics of PSPT under the making a plan step according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	16.68	27.24
	SD	8.086	12.863
	Minimum	0	7
	Maximum	32	55
	N	34	34
EG	Mean	21.09	35.03
	SD	9.399	15.565
	Minimum	4	7
	Maximum	46	66
	N	33	33

The Table 4.1.5 shows that the difference between pre-test and post-test in experimental group is more than that in control group. There is a difference between changes of the scores in PSPT under carrying out the plan step. That means experimental group is more successful in carrying out the step both in pre test and post-test. Moreover there is a bigger change between pre test and post-test results in experimental group.

Table 4.1.6. Descriptive statistics of PSAS according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	93.00	101.82
	SD	25.195	24.221
	Minimum	48	39
	Maximum	147	153
	N	34	34
EG	Mean	103.15	99.06
	Std. deviation	26.717	31.206
	Minimum	50	39
	Maximum	167	170
	N	33	33

In contrast to the PSPT scores, Table 4.1.6 shows that according to the results of PSAS, experimental group's post-test mean is lower than that in pre-test unlike the control group. Experimental group's attitude toward problem solving changed negatively on the other hand control group's attitude changed positively, although there was a small difference in experimental group's results. There are standard deviations shown in Table 4.6 also. It shows that the answers of the experimental group distributed in a larger scale in post-test of PSAS.

Table 4.1.7. Descriptive statistics of MAS according to pre-test and post-test results

Groups	Statistics	Pre-test	Post-test
CG	Mean	44.00	50.41
	SD	16.615	18.905
	Minimum	19	20
	Maximum	88	91
	N	34	34
EG	Mean	46.24	50.39
	SD	17.099	19.200
	Minimum	20	20
	Maximum	90	96
	N	33	33

As seen in Table 4.1.7 it is clearly seen that mean differences between post-test and pre-test in control group are higher than those of experimental group. Attitude toward mathematics was higher than control group in experimental group according to the pre test of MAS. After the treatment, like PSPT, experimental group's decisions changed in positive way but when they are compared with control group there is a smaller change between pre test and post-test of MAS.

4.2 Results of Inferential Statistics

In this section there are results of inferential statistics of the main problems of the study. The results of sub-problems of the study will be given with their hypotheses and tested at a significance level of .05.

To examine the hypothesis of the sub-problem the assumptions of independent t-test were tested. The first one was related to the normality assumption. It was tested by using Kolmogorov-Smirnov Test. The results of this test was given in Table 4.2.1.

Table 4.2.1. Results of Kolmogorov-Smirnov Test for normality assumptions

Variables	Group	Statistic	Sig.
Gained-US	CG	.168	.016
	EG	.087	.200
Gained-PS	CG	.073	.200
	EG	.090	.200
Gained-CPS	CG	.108	.200
	EG	.101	.200
Gained-PSAS	CG	.125	.200
	EG	.197	.200
Gained-MAS	CG	.177	.193
	EG	.194	.002

As seen in Table 4.2.1 The normality assumptions were violated for Gained-US and Gained-MAS of CG and Gained MAS of EG. However the other variables were satisfied for both CG

and EG. To test the normality assumption Skewness and kurtosis vales for each variable for both group was also computed. The results were given in Table 4.2.2.

Table 4.2.2. Skewness - kurtosis of gained scores of PSPT, PSAS and MAS

	Group	N	Skewness	Kurtosis
Gained-US	EG	33	-.211	-.676
	CG	34	-.371	-.299
Gained-PS	EG	33	-.283	-.841
	CG	34	-.030	-.574
Gained-CP	EG	33	-.234	-.145
	CG	34	.307	-.444
Gained-PSAS	EG	33	-.767	1.188
	CG	34	.482	2.043
Gained-MAS	EG	33	1.432	4.527
	CG	34	-.049	1.227

As seen in Table 4.2.2. the skewness and the kurtosis values of the variables were between -2 and +2 except kurtosis values of Gained-PSAS and Gained-MAS of CG. In other words, only these two variables were violated the normality assumptions.

Despite of the results of the tests mentioned above we accepted the all variables satisfied the normality assumption of independent t-test analysis because the number of students was 33 and 34 in treatment groups. Its reason was based on the idea of Hinkle, Jurs and Wiersma, (2003, p.164) who stated that "the sample size is greater than 30, the approximation of the sampling distribution to a normal distribution is usually quite close even if the population is not normally distributed".

The second assumption of the independent samples t-test was related to equality of error variances. It was examined by using Levene's test. The results were given in Table 4.2.3.

Table 4.2.3 Levene's test for equality of error variances

Variables	F	Sig
Gained-US	.035	.853
Gained-PS	.124	.726
Gained-CPS	.003	.954
Gained-PSAS	1.862	.177
Gained-MAS	.908	.344

As seen in Table 4.2.3 the equality of error variances assumption was satisfied for all variables ($p>.05$)

4.2.1 Results of Testing of the First Sub Problem

The first main problem of the study is "What is the effect of Problem Solving Method on 9^{th} grade students" problem solving performance on Functions?". To investigate the first sub-problem following null hypotheses were stated:

H_0 1.1: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "understanding the problem" step.

H_0 1.2: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "making a plan" step.

H_0 1.3: There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "carrying out the plan" step.

They were examined by using the independent samples t-test. The results were given in Table 4.2.4.

Table 4.2.1.1. Results of t-test analysis for gained scores of PSPT

Variables	Group	Mean	SD	t	Sig
Gained-US	CG	8.15	6.787	.582	.563
	EG	7.21	6.353		
Gained-PS	CG	7.65	5.672	-.893	.375
	EG	8.91	5.892		
Gained-CP	CG	10.56	10.130	-1.352	.181
	EG	13.94	10.329		

As seen in Table 4.2.4 it was found that there was no statistically significant mean difference between the students taught by PSM and those taught by TM with respect to gained scores in performance on "understanding the problem" step ($p>.05$). However, the Gained-US mean score of CG was greater than the mean score of EG ($M_{CG}=8.15$, $SDC_{GE}=6.787$; $M_{EG}=7.21$, $SD_{EG}=6.353$). The results was also revealed that there was no statistically significant mean difference between the students taught by PSM and those taught by TM with respect to gained scores in performance on "making a plan" step ($p>.05$). However, the Gained-PS mean score of EG was higher than the mean score of CG ($M_{EG}=8.91$, $SD_{EG}=5.892$; $M_{CG}=7.65$, $SD_{CG}=5.672$). The last finding on PSPT was that there was no statistically significant mean difference between the students taught by PSM and those taught by TM with respect to gained scores in performance on "carrying out the plan" step ($p>.05$). However, the Gained-CP mean score of EG was higher than the mean score of CG ($M_{EG}=$ 13.94, $SD_{EG}=10.39$; $M_{CG}=10.56$, $SD_{CG}=10.130$)

4.2.2 Results of Testing of the Second Sub Problem

To investigate the second sub-problem following null hypothesis was stated as "There is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude toward problem solving. It was tested by the independent samples t-test. The results of this analysis were given in Table 4.2.5.

Table 4.2.2.1 Results of t-test analysis for gained scores of PSAS

Variable	Group	Mean	SD	t	df	Sig
Gained-PSAS	CG	8.82	16.814	2.432	65	.018
	EG	-4.09	25.832			

As seen in Table 4.2.5. it was found that there was a statistically significant mean difference between the students taught by PSM and those taught by TM in the favour of CG with respect to gained scores in attitude toward problem solving. The Gained-PSAS mean score on PSAS of CG was higher than the Gained-PSAS mean score of EG (M_{CG}=8.82, SD_{CG}=16.814; M_{EG}=-4.09, SD_{EG}=25.882).

4.2.3 Results of Testing of the Third Sub Problem

To investigate the third sub-problem following null hypothesis was stated that there was no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude toward mathematics. It was tested by the independent samples t-test analysis. The results of the analyses were given in Table 4.2.6.

Table 4.2.3.1 Results of t-test analysis for gained scores of MAS

Variable	Group	Mean	SD	t	df	Sig
Gained-MAS	CG	6.41	11.639	.658	65	.511
	EG	4.15	16.074			

As seen in Table 4.2.6 it was found that there was no statistically significant mean difference between the students taught by PSM and those taught by TM with respect to gained scores in attitude toward mathematics. However, the Gained-MAS mean score of CG was greater than the Gained-MAS mean score of EG (M_{CG}=6.41, SD_{CG}=11.639; M_{EG}=4.15, SD_{EG}=16.074).

4.3 Conclusions

According to the results of the Problem Solving Performance Test, there is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in performance on "understanding the problem" step, "making a plan" step, and "carrying out the plan" step. When the attitude scales are taken in attention there is statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude toward problem solving. On the other hand there is no statistically significant mean difference between the students taught by Problem Solving Method and those taught by Traditional Method with respect to gained scores in attitude toward mathematics.

CHAPTER 5

DISCUSSIONS AND RECOMMENDATIONS

This chapter includes discussions and interpretations of the results, internal and external validity and recommendations.

5.1. Discussions

The main purposes of this study were to investigate the students' gained scores in problem solving performance and attitude toward problem solving and mathematics.

5.1.1. Discussion of PSPT results

There was no statistically significant mean difference between the experimental group and control group students with respect to gained scores in performance on "understanding the problem", "making a plan", and "carrying out the plan" steps. When studies of some researchers are taken into consideration, it was found out that results were either consistent or inconsistent with the present study.

Literature shows that Problem Solving Method is an effective way of teaching mathematics (eg. Hammorui, 2003; Koç, 1998; Özkaya, 2002; Ubuz, 1991) Yet, it was not the case in the present study. For instance, Koç (1998) studied with the 7^{th} grade students and he used three different kinds of the teaching methods. He expressed that one of the effective ways to teach mathematics is Problem Solving Method. The difference between the present study and Koç's (1998) is the age of the participants. That is, the participants in the present study were older than those in Koç's study (1998); he studied with 7^{th} graders. The older the students are the more they regret the new things. This is a typical reaction for adolescents who are high

school students (Atwell,1998). Due to their age, some problems such as demotivation and unwillingness to solve problems were faced. However in Koç's study (1998), as the participants were younger, they might be more competitive and motivated. Almost every book, journal and research was prepared on Problem Solving Method in primary school, which has problems or activities in basic level for high school students. Age was important at the time of designing the activities and problems for this study. Preparing problems and examples for the adolescences was very different from doing in primary school. The reactions of the students in pilot study were the origin of this decision. Furthermore, according to Atwell (1998) adolescents have poor attitude.

Another study was Özkaya's (2002); which was not convenient with the present study. The study was based on 10^{th} grade students' beliefs and problem solving achievement in Geometry. Students' Geometry achievement has increased who were taught by Problem Solving Method in Özkaya's (2002) study. Geometry might be one of the most appropriate parts of mathematics. The results of the Özkaya's study (2002) showed that students tended to choose a strategy which was the most appropriate for the problem. Students' choice was not one of the components of the present study. There might be a problem in the students' choice when they were solving a problem.

5.1.2. Discussion of PSAS results

There was a significant mean difference between experimental group and control group gained scores in PSAS in a negative way. Although there was not a significant difference, the gained scores of PSPT of the experimental group were greater than that of control group. That result was supported by Kloosterman (2002); he says that connection with the students' beliefs and motivation is not as strong as it is believed. That result shows that the experimental group students' attitude toward problem solving changed in negative way after

they learned how to solve a real problem. Their behaviors changed at the end of the experiment also. Experimental group students did not want to solve problems any more. Their decision was in that way: if they would solve a problem, they had to think too much and undergo a long process.

Yavuz (2006) studied on problem solving in 9th grades; however the results of Yavuz (2006) were inconsistent with the results in the present study. The study of Yavuz (2006) was based on the progress on the 9th grade students' affective domain. The results showed that teaching Problem Solving Method increased the 9th grade students' affective domain.

Students who were taught by Problem Solving Method understood that solving problems is a hard work not as easy as some common word problems such as age problems, pool problems and velocity problems etc. which are commonly known as "word problems". On the other hand, control group students did not recognize the difficulty of problem solving. Thus, according to experimental group students' answers in students reports, experimental group students thought that they had to think twice before solving a problem, while control group thought they could easily solve problems.

5.1.3. Discussion of MAS results

There was no significant mean difference in the students' gained scores with respect to MAS. That result showed that Problem Solving Method did not change the students' attitude toward mathematics. However the literature states that using different teaching methods increases students' attitudes toward mathematics (eg. Akman, 2005; Hanley, 1995; Kandemir, 2006; Koç, 1998; Mayo, 1994; McLoad, 1989; Özkaya, 2002). Only few studies showed that there was no relationship between mathematics attitudes and success (eg. Yavuz, 2006; Yılmaz, 2007). Problem Solving Method did not affect the students' attitude toward mathematics in the present study. The reasons would be the awareness of problems like PSAS results

showed. After the elementary school, students generally took the general exams with multiple choice items. Thus students tend to solve any question in short and fast way. Problem Solving Method might be seemed to be long and useless process for them.

5.2 Internal Validity of the Study

According to Fraenkel and Wallen (1996) the internal validities of an experimental study is listed below. These internal validities are explained according to their (possible) effect of this study.

Instrumentation: The same instruments were given to the students at the same time. PSPT pre-test and post-test were done in the first lesson on Monday morning to eliminate negative effect of instrumentation, history, and implementation.

Mortality: In some studies participants may be absent when the tests/scales were taken. In the present study, there was no loss of subjects.

Testing: Test items were interesting to the participants. That is to say, there might be an effect on all the participants of the study. They saw the problems of the pre-test and they learned the subject functions. Students might be interested in these problems; they would search on the problems and functions itself.

Maturation: It could not be said that there was a maturation effect in the study. The study took only seven weeks and it was in the first semester of the year.

Attitude of subjects: All the students in experimental group and control group were warned to be in an experimental study. All the students answered the scales and tests honestly. They were happy to help their teacher.

Subject characteristics: Experimental and control groups were equivalent in terms of attitude toward mathematics, attitude toward mathematical problem solving, mathematical problem solving performance and prior mathematics achievement at the beginning of the treatment.

Location: The control and experimental groups were in the same school to satisfy the requirement of location validity.

5.3 External Validity of the Study

There are two dimensions of external validity. They are population generalizability and ecological generalizability (Fraenkel & Wallen, 1996).

Population generalizability: In the present study convenience sampling method was used to obtain the sample of the population. Thus, this method limits the population generalizability of the research results according to the idea of Fraenkel and Wallen (1996) who stated that convenience samples could not be considered representative of any population.

Ecological generalizability: The present study was applied in a private school and results could be generalized to the students in a private school that has similar conditions with the school in this study.

5.4 Recommendations of the study

The recommendations of this study are listed below:

High school years were seemed to be late to get used to solve problems in a specific sequence. Students might be more attentive if they knew Problem Solving Method before. Mathematics teachers in primary schools should express the importance of problem solving to the students. Teachers should increase the awareness of the students on problem solving. The way of doing it is integration that into their lesson.

Mathematics textbook authors should give more emphasis on the Problem Solving Method to improve students' competency on problem solving by taking into account the new mathematics curriculum.

When a similar study is carried out, the following points should be taken into consideration:

• The 9th graders in 2009-2010 know problem solving more than the students in this study. In other words, a study similar to this one could be done in 2009-2010 academic year or later to examine the effectiveness of Problem Solving Method.

• Some studies could be done to examine how to integrate the Problem Solving Method into different subjects of high school Mathematics.

• Students' attitudes might be changed after they learned what the problem solving is. Students' knowledge and beliefs are important when a study similar to this take place. A study should be done on high school students' beliefs about problem solving.

• There could be different results according to the different participants. This study could be done in different kinds of schools.

REFERENCES

Aşkar, P. (1986). *Matematik dersine yönelik tutum ölçen likert-tipi bir ölçeğin geliştirilmesi.* Eğitim ve Bilim, 11, pages 31–36.

Akman, C. (2005). *The Effects Instruction with Analogy-Enhanced Model on Ninth Grade Students' Function Achievement and Attitudes Toward Mathematics.* Master's thesis, Middle East Technical University.

Armour-Thomas,E., & Artzt,A.F. (1992) *Development of a Cognitive-Meta cognitive Framework for Protocol Analysis of Mathematical Problem Solving in Small Groups.* Cognition & Instructions, 1992, 9(2) pages 137-175 Lawrence Erlbaum Associates, Inc.

Atwell, N. (1998). *In the Middle: New Understandings About Writing, Reading, and Learning.* Boynton/Cook.

Bershadsky,I., Lavy,I (2003) *Problem Posing via "what if not?" Strategy in Solid Geometry, Journal of Mathematical Behavior,* 22(2003) 369-387

Blount, N., & Klausmeier, H. (1968). *Teaching in the secondary school third edition.* Harper& Row Publishers.

Bourne,Jr, L.E., & Dominowski, R.L. (1994) *History of Research on Thinking and Problem Solving.* Thinking and Problem Solving Handbook Perception and Cognition Second Edition, Edited by Robert J. Sternberg. Chapter 1 pages 1-35

Charles, R., Lester, F., & O'Daffer, P. (1987). *How to evaluate progress in problem solving.*NCTM, Inc, Reston.

Dickerson,V.M., (1999) *The Impact of Problem-posing Instruction on the Mathematical Problem-solving Achievement of Seventh Graders*. Emory University

English,L.D., (1997) *The Development of Fifth-Grade Children's Problem-Posing Abilities.* Educational Studies in Mathematics 34: 183-217 Kluwer Academic Publishers. Printed in Netherlands.

Fraenkel, J., & Wallen, N. (1996). *How to Design and Evaluate Research in Education*. NewYork: Mc Graw-Hill, Inc.

Garofalo,J., & Lester,F.K.(1985) *Meta cognition, cognitive monitoring, and mathematical performance* . Journal for Research in Mathematics Education, 16 pages 163-176

Grundmeier,T.A., (2003) *The Effects of Providing Mathematical Problem Posing Experiences for K-8 Pre-Service Teachers: Investigating Teachers' Beliefs and Characteristics of Posed Problems.* The University of New Hampshire

Hammouri, H.A.M(2003). *An Investigation of Undergraduates' Transformational Problem Solving Strategies: cognitive/meta cognitive processes as predictors of holistic/analytic strategies.* Assessment & Evaluation in Higher Education. Vol. 28, No. 6, December 2003 Carfax Publising, Zarqa,Jordan

Holton, D. (1994). *Mathematics Education: A handbook for teachers*, vol. 1. National Council of Teachers of Mathematics.

Hunt,E.(1994) *Problem Solving History of Research on Thinking and Problem Solving.* Thinking and Problem Solving Handbook Perception and Cognition Second Edition, Edited by Robert J. Sternberg. Chapter 7 pages 215-232

Kandemir,M.A.,(2006) *Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü Matematik Öğretmen Adaylarının Yaratıcılık Eğitimi Hakkındaki Görüşleri ve Yaratıcı Problem Çözme Becerilerinin İncelenmesi.* Yüksek Lisans Tezi. Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Matematik Eğitimi Anabilim Dalı

Kayan, F. (2007). *A study on preservice elementary mathematics teachers' mathematical problem solving beliefs.* Master's thesis, Middle East Technical University.

Kloosterman, P. (2002). *Beliefs: A hidden variable in mathematics education.* Kluwer Academic Publishers.

Koç, Y. (1998). *The Effect of Different Teaching Methods on Mathematical Problem Solving Performance.* Master's thesis, Middle East Technical University.

Krulik, S., & Posamentier, A. (1998). *Problem Solving Strategies for Effcient and Elegant Solutions.* Corwin Press Inc.

Krulik, S., & Rudnick, A. (1987). *A handbook for teachers second edition.* Ally and Bacon Inc.

Mayo, E. (1994). On power and equity: Let's not blame the victim. In J. Neyland (Ed.) *Mathematics Education: A Handbook for Teachers*, vol. 1 of Mathematics Education: A Handbook for Teachers. Wellington Collage of education.

McLoad, D. (1989). *The Role of Affect in Mathematical Problem Solving*. Springer-Verlag Inc.

MoNE (2005). Milli Eğitim Bakanlığı Orta Öğretim Matematik Müfredatı. Talim Terbiye Kurulu MEB.

MoNE-EARGED (2003). TIMSS 1999 Projesi Matematik ve Fen Bilgisi Çalışması Ulusal Rapor 2003. Milli Eğitim Bakanlığı, Eğitimi Araştırma ve Geliştirme Başkanlığı

MoNE-EARGED (2005). PISA 2003 Projesi Ulusal Nihai Raporu 2005. Milli Eğitim Bakanlığı, Eğitimi Araştırma ve Geliştirme Başkanlığı

Nuangchalerm, P, Pimta,S , Tayruakham,S, (2009) *Factors Influencing Mathematics Problem solving Ability of Sixth Grade Students*, Journal of Social Sciences 5(4):381-385,2009

NCTM(1989). Principles and Standards for SchoolMathematics. National Council of Teachers of Mathematics.

NCTM(1991). Professional standards for TeachingMathematics. National Council of Teachers of Mathematics.

NCTM(2000). Principles and Standards for SchoolMathematics. National Council of Teachers of Mathematics.

North, L. (1992). *T2-TV supplemental materials, scientific literacy*. Illinois council of teachers of mathematics.

Olowa,O.W, (2009) *Effects of the Problem Solving and Subject Matter Approaches on the Problem Solving Ability of Secondary School Agricultural Education*, Journal of Industrial Teacher Education, v46 n1 p33-47 Spr 2009

Owens,M.E., (1999) The Relationships of Cognitive Learning Styles Mathematics Attitude, and Achievement in a Problem Posing Classroom. Dissertation presented for Doctor of Philosophy Degree. The University of Tennessee, Knoxville

Öğrenci Seçme ve Yerleştirme Sistemi ile ilgili sayısal bilgiler <http://www.osym.gov.tr/Genel/BelgeGoster.aspx?F6E10F8892433CFFAC8287D72AD903BE8F59EC4393613791> (2010, March 27)

Özkaya, S.S. (2002) Investigation of Tenth Grade Students' Problem Solving Strategies inGeometry. Master's thesis, Middle East Technical University.

Özsoy,G. (2007) İlköğretim Beşinci Sınıfta Üstbiliş Stratejileri Öğretiminin Problem Çözme Başarısına Etkisi. Doktora tezi, Gazi Ünivetrsitesi.

Pallant,J. (2001) SPSS Survival. Manual. Milton Keynes: Open. University Press. ROYAL COLLEGE OF PSYCHIATRISTS.

Polya,G. (1945). *How to Solve it*, Garden City, New York: Doubleday

Polya, G. (1973). *How to Solve it*, a new aspect of mathematical Method. Princeton University Press.

Posamentier, A., & Stepelma, J. (2002). *Teaching Secondary school Mathematics* (Techniques and Enrichment Units). Merrill Prentice Hall.

Rips,L.J.,(1994) *Deductive Reasoning History of Research on Thinking and Problem Solving.* Thinking and Problem Solving Handbook Perception and Cognition Second Edition, Edited by Robert J. Sternberg. Chapter 5 pages 149-178

Sakshaug, E., Olson, M., & Olson, J. (2002). Children Are Mathematical Problem Solvers. National Council of Teachers of Mathematics.

Schoenfeld, A.H.(1983) *Episodes and Executive Decisions in Mathematical Problem Solving*. R.Lesch&M.Landau(Eds.) Acquisition of Mathematical Concepts and Processes pp 345-395 New York, Academic

Sinclair,J. (Ed. In Chief) (1993). *Collins COBOUILD English Language Dictionary*. London: Harper Collins Publishers

Snelbecker, G. (1974). *Learning Theory, Instructional Theory, and Psychoeducational Design.* Mcgraw-Hill,Inc.

Swan,M. (1985). *The Language of Functions and Graphs*. Shell Centre & Joint Matriculation Board.

Tebliğler Dergisi (1974) Ortaokul Matematik Programı.

Ubuz, B. (1991). *The effect of Problem Solving Method with handout material on achievementin solving calculus word problems.* Master's thesis, Middle East Technical University.

Western Michigan University. The Evaluation Center. Glossary of Program Evaluation Terms, <http://ec.wmich.edu/glossary/prog-glossary.htf> (2010, March 20)

Yavuz, G(2006) *Dokuzuncu Sınıf Matematik Dersinde Problem Çözme Strateji ve Öğretiminin Duyuşsal Özellikler ve Erişiye Etkisi.* Dokuz Eylül Üniversitesi Eğitim Bilimleri Enstitüsü Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Matematik Öğretmenliği Bilim Dalı. Doktora Tezi

Yıldız, V. (2008). *Investigation of the change in sixth grade students' problem solving abilities, attitude toward problem solving and attitude toward mathematics after mathematics instruction based on polya's problem solving steps.* Master's thesis, Middle East Technical University.

Yılmaz,K. (2007) *Öğrencilerin Epistemolojik ve Matematik Problemi Çözmeye Yönelik İnançlarının Problem çözme Sürecine Etkisinin Araştırılması.* Marmara Üniversitesi Eğitim Bilimleri Enstitüsü Ortaöğretim Anabilim Dalı Matematik Öğretmenliği Bilim Dalı. Yüksek Lisans Tezi

Zeitz, P. (1999). *The Art and Craft of Problem Solving.* John Wiley & Sons Inc.

APPENDIX A

PSPT

PROBLEM ÇÖZME TESTİ

1. Bir bitkinin boyundaki değişim ile ilgili aşağıdaki bilgiler verilmiştir.

- ❖ Bitkinin fidesi dikildiğinde fide 15cm idi.
- ❖ Bitki her yıl 7cm uzamaktadır.

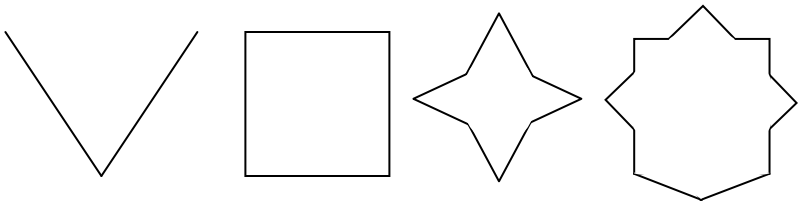
Buna göre bitkinin dikildikten 25 yıl sonraki uzunluğu kaç cm olur?

Bu sonuca nasıl vardığınızı matematik bilgilerinizi kullanarak açıklayınız.

Çözüm:

2. Aşağıdaki şekiller sırasıyla, f(x) fonksiyonunun A={2,3,5,7,8} tanım kümesindeki elemanlara karşılık gelen f(2), f(3), f(5) ve f(8) görüntüleridir. Buna göre,

- ❖ f(x) fonksiyonunun kuralını yazınız. (Şeklin kenar sayısı ile x arasındaki ilişkiyi dikkate alınız.)
- ❖ f(7) görüntüsüne denk gelen bir şekil çiziniz.



Çözüm:

3. Beril yürüyerek okula 30 dakikada, koşarak 15 dakikada gelebilmektedir. Beril'in evi ile okul arası 450m olduğuna göre Beril'in yürüme hızı kaç m/dk dır?

Çözüm:

4. Aşağıdaki şeklin f ve g fonksiyonlarının altındaki görüntüleri verilmiştir. Buna göre bu şeklin $f \circ g$ ve $g \circ f$ bileşke fonksiyonları altındaki görüntülerini nedenini açıklayarak çiziniz.

Çözüm:

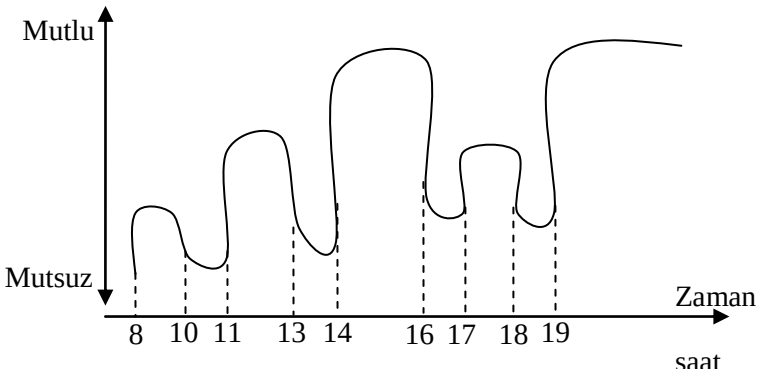
....

....

5. Geçen ay içinde Aslı'nın bir günkü ders programı ve o günkü ruh halini gösteren grafik verilmiştir. Buna göre aşağıdaki soruları cevaplayınız.

a) Grafiğe göre, Aslı'nın en çok zevk aldığı ders nedir?

b) Grafiğe göre Aslı'nın en sevmediği ders nedir?



Ders Başlama Saati	**Ders**
9:00	Matematik
10:00	Fizik
11:00	Müzik
12:00	Öğlen Arası
13:00	Türkçe
14:00	Tarih
15:00	Tarih
Saat 15:50 de okul bitmektedir.	

c) Aslı'nın saat 16:00 dan sonra ne gibi aktiviteler yaptığını, ruh halinden yararlanarak yorumlayınız. (Örnekler kullanabilirsiniz.)

Çözüm:

6.

Verilenler: *f(1)=4, f(2)=7, f(4)=13, f(5)=16*

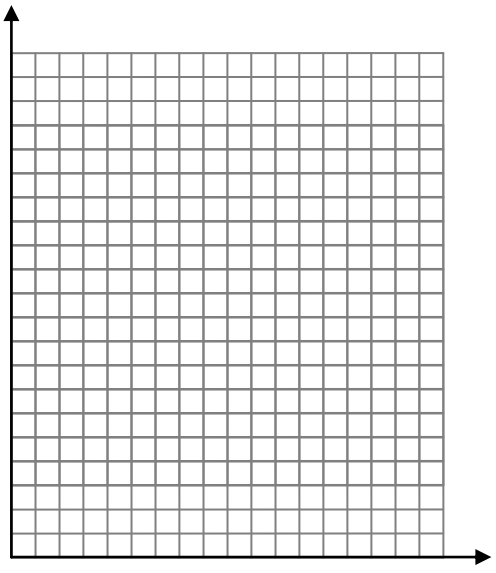
Yukarıdaki verilenler listesine göre fonksiyon ile ilgili bir problem yazınız ve çözümünü yapınız.

Çözüm:

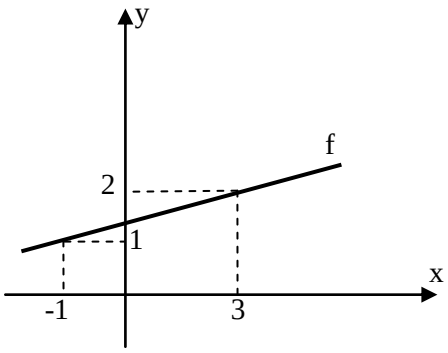
7. Aşağıda bir maddenin $27^{\circ}C$ ile $37^{\circ}C$ arasında belli sıcaklıktaki kütle değişimlerine ait fonksiyonun kuralı verilmiştir. Buna göre; sıcaklık ile kütle arasındaki ilişkiyi gösteren bir grafik oluşturunuz. (x, sıcaklığı göstermektedir.)

$$f(x) = 100 - (x - 27)^2$$

Çözüm:



8. f fonksiyonunun grafiği yanda verilmiştir Buna göre f(0) değerini hesaplayınız.



Çözüm:

f(3)=2 ve f(-1)=1 dir.

f(x) bir doğru belirttiğine göre doğrusal fonksiyondur. O halde

f(x)=ax+b şeklindedir.

f(3)=3a+b=2

f(-1)= -a+b=1

f(3)-f(-1)=4a=3.....a= $\frac{3}{4}$ *tür.*

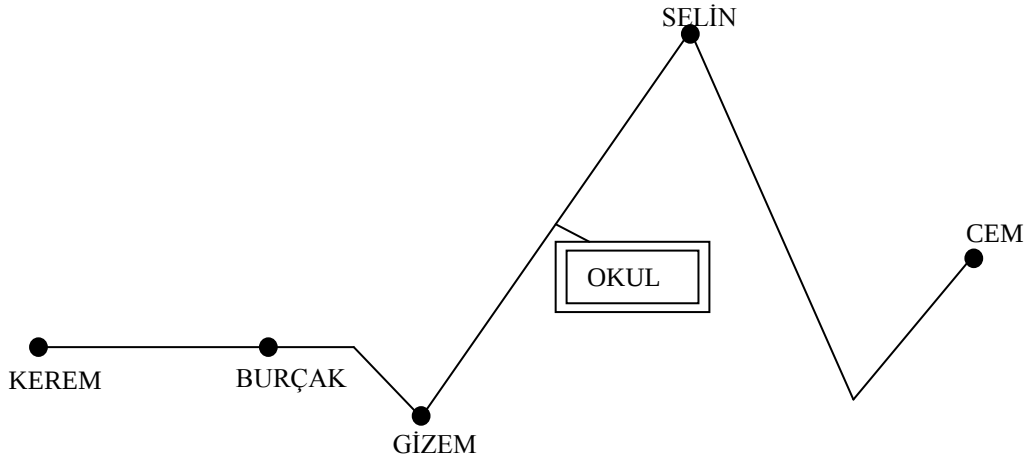
Buradan, $-\frac{3}{4}+b=1$*.....b=* $\frac{7}{4}$ *tür.*

Böylece; f(0)= $\frac{3x+7}{4}$ *olur.*

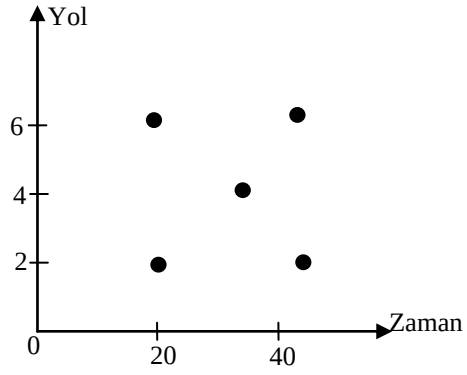
Yukarıda problem ve çözümün bir aşaması verilmiştir. Bu çözüm hakkında yorum yapınız.

Çözüm:

9. Kerem, Burçak, Gizem, Selin ve Cem okula her gün aynı yolu kullanarak gitmektedir. Aşağıdaki harita kimin nerede oturduğu ve okulun yerini göstermektedir.



Cem'i babası her gün arabayla okula bırakmaktadır. Her zaman Kerem bisikletle, Gizem ise yürüyerek okula gitmektedir. Diğer iki öğrenci okula her gün farklı şekilde gelmektedir. Aşağıdaki grafik, her bir öğrencinin geçen Pazartesi günü okula gelişi sırasında geçen zamana ilişkin bilgileri vermektedir.



a) Grafikteki her bir noktanın üzerine hangi öğrenciye ait olduğunu yazınız.

b) Grafikten yararlanarak, Burçak ve Selin'in Pazartesi günü okula nasıl gittiğini tespit ediniz.

c) Yukarıdaki cevaba (b) nasıl ulaştığınızı anlatınız.

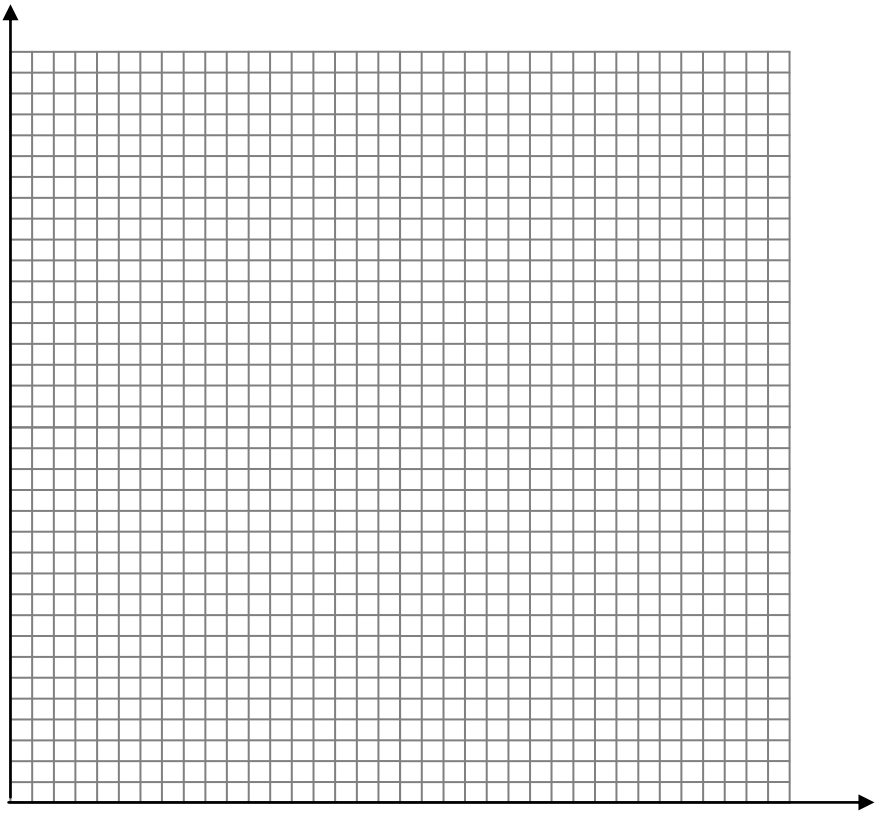
Çözüm:

10. Bir şirketin kafeteryasında bulunan kutu içecek makinesinin normal bir gündeki çalışma sistemi ile ilgili aşağıdaki bilgiler verilmiştir.

- ❖ Makine her güne yarı dolu olarak başlar.
- ❖ Sabah 9 dan önce ve akşam 17 den sonra makineden içecek satışı olmamaktadır.
- ❖ Makineden içecek satışı, yoğun talebin olduğu molalar (sabah 10:30-11:00 ile öğlen 13:00-14:00 arası) hariç çok değildir.
- ❖ Makineye öğle molasından az önce dolum yapılmaktadır. (Bu dolum 10 dakika sürmektedir.)

Aşağıdaki tabloya sabah 8 ile akşam 18 arasında, içecek makinasındaki içeceklerin miktarının zamana göre değişimini gösteren grafiği çiziniz. (Grafik çizimine noktasal grafikle başlayıp, sonra noktaları birleştirmeniz tavsiye edilir.)

Çözüm:



APPENDIX B

RUBRIC of PSPT

PROBLEM ÇÖZME TESTİ PUANLAMA ANAHTARI

ANLAMA	
4	Problemde verilenler ve istenenler anlaşılmıştır.
3	Problemde verilenler anlaşılmış; ancak neyin istendiği anlaşılmamıştır.
2	Problemde verilenler ve istenenler arasındaki bağlantı kavranamamıştır.
1	Problemde verilen eksik/fazla bilgiyi doğru değerlendirememiştir.
0	Problemde verilenler ve istenenler anlaşılmamıştır.
PLAN YAPMA	
4	Problemin çözümü için doğru, sonuca ulaştıracak bir strateji oluşturulmuştur.
3	İstenenlere ulaşmak için sadece ilk basamak düşünülerek bir strateji oluşturulmuştur.
2	Problemin çözümü için yanlış, sonuca götürmeyecek bir strateji oluşturulmuştur.
1	Problemin çözümü için seçilen strateji anlaşılmamaktadır.
0	Bir plan yapılmadığı açıkça görülmektedir.
PLANI UYGULAMA	
7	Doğru strateji seçilerek doğru sonuç bulunmuştur.
6	Doğru strateji seçilmiş ve yürütülmüş; ancak basit hatadan(yanlış yazma, işlem hatası vb.) dolayı yanlış sonuca ulaşılmıştır.
5	İşlemler/yorumlar, yazılmış ve doğrudur ancak; yapılmamıştır.
4	Seçilen strateji yürütülemediği için yanlış sonuca ulaşılmıştır.
3	Alt basamaklara doğru ulaşılmış ancak asıl sonuca ulaştıracak yol bulunamamıştır.
2	Yanlış strateji seçildiği için yanlış sonuca ulaşılmıştır.
1	İşlemlerin/yorumların bir kısmı anlaşılır/mantığa uygun değildir.
0	Hiç işlem/yorum yapılmamıştır veya çözümle ilgisiz işlemler/yorumlar yapılmıştır.

APPENDIX C

PSAS

PROBLEM ÇÖZMEYE YÖNELİK TUTUM ÖLÇEĞİ

İsim-Soyisim:.....

AÇIKLAMA: Aşağıda problem çözmeye ilişkin tutum cümleleri ile her cümlenin karşısında "Kesinlikle Katılıyorum", "Katılıyorum", "Kararsızım", "Katılmıyorum", "Hiç Katılmıyorum" olmak üzere beş seçenek verilmiştir. Her bir cümleyi dikkatli okuyarak, **boş bırakmadan** bu cümlelere ne ölçüde katıldığınızı seçeneklerden birini işaretleyerek belirtiniz. Bu cümlelerin **doğru** ya da **yanlış** cevapları bulunmamaktadır. Yalnızca sizin doğru bulduğunuz cevaplar doğru kabul edilmektedir. Mümkün olduğunca yaşadıklarınızı düşünerek karar veriniz. Bu anket yalnızca araştırma amacıyla kullanılacaktır ve verdiğiniz cevaplar **kesinlikle gizli tutulacaktır.** Yardımlarınız için çok teşekkür ederiz.

	Kesinlikle Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1. Problem çözmek beni huzursuz eder.					
2. Problemleri, sadece cevap vermiş olmak için öylesine çözerim.					
3. Zor problemlerle uğraşmayı severim.					
4. Problem çözmeye çalışmak sıkıcıdır.					
5. Problem çözmek düşünme yeteneğimi geliştirir.					
6. Problem çözerken kafam karışmaz.					
7. Problemlerin çözümüyle ilgili fikirlerimin, diğer çocuklarınki kadar iyi olmamasından endişe duyarım.					
8. Bir cevap buluncaya kadar problemle uğraşmaktan hoşlanırım.					
9. Bir problem üzerinde uzun süre uğraşmak beni sıkmaz.					
10. Problem çözmeye çalışmaktan hoşlanırım.					
11. Matematik dersinde problem çözerken kazandığım beceriler bana diğer derslerimde yardımcı olmaz.					
12. Öğretmenim tahtada bi matematik problemini çözerken sıkıntı duyarım.					
13. Bir problemi çözüm yolunu öğrendikten sonra benzer problemleri çözebilirim.					
14. Bir problemin birden fazla çözümünü bulmaya çalışmak zihinsel gelişim açısından yararlıdır.					

15. Matematik problemlerini çözmek bana çekici gelmiyor.					
16. Zor matematik problemleri ile uğraştığımı düşündüğüm zaman, kendimi çaresiz hissederim.					
17. Matematik problemi çözerken öğrendiklerimin bana gerçek yaşamda yardımcı olacağına inanmıyorum.					
18. Bir problemin çözümünü sınıfta tartışmak zevkli bir iştir.					
19. Problem çözmeyi düşünmek bile sinirlerimi bozuyor.					
20. Çözmeyi denemeyeceğim bazı problemler vardır.					
21. Anlaşılması zor problemlerle bile uğraşırım.					
22. Problemlerin çoğunu çözebileceğime eminim.					
23. Bir problemin çözümünü veren denklemi bulabilirim.					
24. Bir problemi değişik yöntemlerle çözerim.					
25. Problem çözmek beni korkutmaz.					
26. Matematik derslerinde problem çözmeye daha çok zaman ayılmasını isterim.					
27. Bir problemi tahtada çözmem istendiğinde endişelenmem.					
28. Gelecekteki çalışmalarımda problem çözme becerilerine ihtiyaç duyacağım.					
29. İyi problem çözebilem birisiyim.					
30. Çoğu problemi çözmek eğlenceli bir iştir.					
31. Problem çözmek matematiğin en zevkli alanıdır.					
32. Matematik problemi çözmenin ilerideki mesleğimde yararlı olacağını düşünmüyorum.					
33. Çoğu zor problemi çözebilirim.					
34. Problem çözme konusunda herkesten daha iyiyim.					
35.Bir problemi nasıl çözdüğümü açıklamam istendiğinde, bundan endişe duymam.					
36. Problem çözerken başarısız olacağımı düşünürüm.					
37. Matematik dersinde problem çözerken kazandığım beceriler bana diğer derslerimde yardımcı olmaz.					
38. Problemleri çözmek için değişik yöntemler düşünürüm.					
39. Problem çözerken zorlanınca hemen vazgeçerim.					

APPENDIX D

MAS

MATEMATİK DERSİNE KARŞI TUTUM ÖLÇEĞİ

Adınız Soyadınız:……..	Cinsiyetiniz:……..				
Okulunuzun İsmi:…….	Sınıfınız:……				
Genel Açıklama: Aşağıda öğrencilerin matematik dersine ilişkin tutum cümleleri ile her cümlenin karşısında					
"Tamamen Uygundur", "Uygundur", "Kararsızım", "Uygun Değildir" ve "Hiç Uygun Değildir" olmak üzere beş seçenek					
verilmiştir. Lütfen cümleleri dikkatli okuduktan sonra her cümle için kendinize uygun olan seçeneklerden					
birini işaretleyiniz.					

	Tamamen Uygundur	Uygundur	Kararsızım	Uygun Değildir	Hiç Uygun Değildir
1. Matematik sevdiğim bir derstir.	O	O	O	O	O
2. Matematik dersine girerken büyük sıkıntı duyarım.	O	O	O	O	O
3. Matematik dersi olmasa öğrencilik hayatı daha zevkli olur.	O	O	O	O	O
4. Arkadaşlarımla matematik tartışmaktan zevk alırım.	O	O	O	O	O
5. Matematiğe ayrılan ders saatlerinin fazla olmasını dilerim.	O	O	O	O	O
6. Matematik dersi çalışırken canım sıkılır.	O	O	O	O	O
7. Matematik dersi benim için angaryadır.	O	O	O	O	O
8. Matematikten hoşlanırım.	O	O	O	O	O
9. Matematik dersinde zaman geçmez.	O	O	O	O	O

	Tamamen Uygundur	Uygundur	Kararsızım	Uygun Değildir	Hiç Uygun Değildir
10. Matematik dersi sınavından çekinirim.	O	O	O	O	O
11. Matematik benim için ilgi çekicidir.	O	O	O	O	O
12. Matematik bütün dersler içinde en korktuğum derstir.	O	O	O	O	O
13. Yıllarca matematik okusam bıkmam.	O	O	O	O	O
14. Diğer derslere göre matematiği daha çok severek çalışırım.	O	O	O	O	O
15. Matematik beni huzursuz eder.	O	O	O	O	O
16. Matematik beni ürkütür.	O	O	O	O	O
17. Matematik dersi eğlenceli bir derstir.	O	O	O	O	O
18. Matematik dersinde neşe duyarım.	O	O	O	O	O
19. Derslerin içinde en sevimsizi matematiktir.	O	O	O	O	O
20. Çalışma zamanımın çoğunu matematiğe ayırmak isterim.	O	O	O	O	O

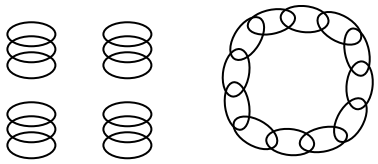
APPENDIX E

SOME PARTS OF EXPERIMENTAL GROUP'S HANDOUTS

1. FARKLI BİR BAKIŞ OLUŞTURMA

Problemin soruluş tarzından farklı bir bakış açısı ile problemi irdelemek hemen görülemeyen çözüme daha rahat ulaşılmasını sağlayabilir.

Problem 6



4 tane 3 lü zincirden sadece 3 halka açılıp kapatılarak şekildeki gibi zincirden bir halka nasıl oluşturulabilir?

Problem16:

$f: \mathbb{R} \to \mathbb{R}$, $f(x)=(n-2)x^2+(m+3)x+m+n$ fonksiyonu sabit fonksiyon ise

$f(\sqrt{3})$ =?

Problem17:

$f:\mathbb{R}\to\mathbb{R}$,f(x)=(m+3)x+(m+n) fonksiyonu birim fonksiyon ise

n=?

Problem18:

$f:\mathbb{R}\to\mathbb{R}$,f(x)=2mx+n doğrusal fonksiyonu için f(1)=2 ve f(2)=8 olduğuna göre

f(-1)=?

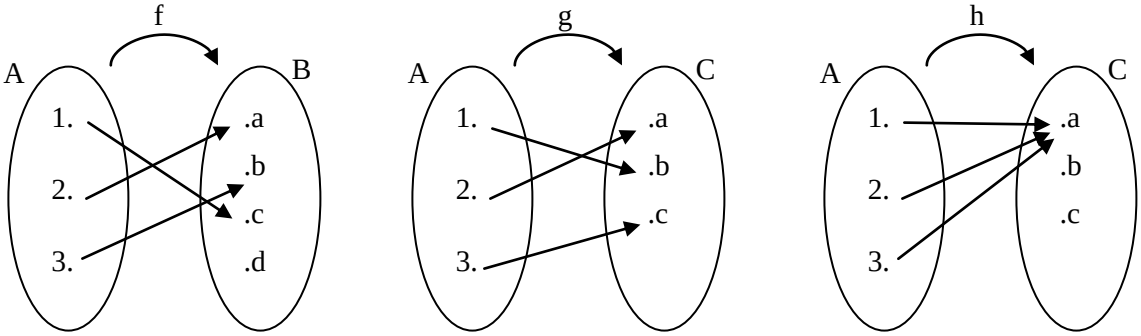
Problem19:

$f: \mathbb{R} \to \mathbb{R}$,f(x)=$(a^2+b)x^2+(a-b)x$ fonksiyonu sıfır fonksiyonu ise

a=?

Alıştırmalar:

1. Aşağıda şeması verilen fonksiyonların türlerini belirtiniz.



2. $f:\mathbb{R}\to\mathbb{R}$,f(x)=(m+n)$x^2$+(2n-1)x+m fonksiyonu sabit fonksiyon ise f(100) =?

3. $f:\mathbb{R}\to\mathbb{R}$,olmak üzere m nin hangi değerleri için aşağıdaki fonksiyonlar sabit fonksiyon olur?

a) f(x)=(3m-1)x+2

b) f(x)= $\frac{x^2+3mx+1}{x^2+2x+1}$

c) f(x)= $\frac{4x^2+mx+4}{2x^2-x+2}$

4. $f:\mathbb{R}\to\mathbb{R}$,f(x)=a$x^2$+(b-2)x+c+3 fonksiyonu sıır fonksiyonu olduğuna göre a,b,c kaçtır?

5. $f:\mathbb{R}\to\mathbb{R}$,, f(x+2)=3x+4 ise f(0)+f(1)-f(2) değerini hesaplayınız.

Problem 20:

A={a,b,c} ve B={1,2,3,4} kümeleri veriliyor. Buna göre A dan B ye kaç tane fonksiyon tanımlanabilir?

Not: A dan B ye tanımlı fonksiyonların sayısı, $s(B)^{s(A)}$ dır.

Problem 21:

A={a,b,c} ve B={1,2,3,4} kümeleri veriliyor. Buna göre A dan B ye kaç tane bire bir fonksiyon tanımlanabilir?

Not: A dan B ye tanımlı bire bir fonksiyonların sayısı, s(B)=n ve s(A)=m olmak üzere, $P(n,m)=\frac{n!}{(n-m)!}$ dir.

Problem 22:

A={a,b,c} ve B={1,2,3,4} kümeleri veriliyor. Buna göre A dan B ye kaç tane sabit fonksiyon tanımlanabilir?

Not: A dan B ye tanımlı sabit fonksiyonların sayısı, s(B) dir.

Problem 23:

A={a,b,c} kümesi veriliyor. Buna göre A dan B ye kaç tane birebir ve örten fonksiyon tanımlanabilir?

Not: A dan B ye tanımlı bire bir ve örten fonksiyonların sayısı, s(B)=s(A)=m olmak

üzere m! dir.

Alıştırmalar:

1. A={a,b,c,d} kümesi veriliyor. A dan A ya tanımlı bire bir olmayan kaç fonksiyon tanımlanabilir?

2. s(A)=2 ve s(B)=4 olmak üzere A dan B ye tanımlı fonksiyon olmayan kaç tane bağıntı vardır?

Fonksiyon Grafikleri

Fonksiyon grafikleri kartezyen çarpım ve bağıntı grafikleri gibi düşünülebilir. Buna göre aşağıdaki örnek grafikleri çizelim.

Örnek 1:

A={0,1,2,3,4} olmak üzere $f: A \to \mathbb{R}$, f(x)=2x+1 fonksiyonunun grafiğini çizelim.

Örnek 2:

A={0, $\frac{1}{2}$,1, $\frac{3}{2}$,2, $\frac{5}{2}$,3, $\frac{7}{2}$,4} olmak üzere $f: A \to \mathbb{R}$,f(x)=2x+1 fonksiyonunun grafiğini çizelim.

Örnek 3:

$f: \mathbb{R} \to \mathbb{R}$,f(x)=2x+1 fonksiyonunun grafiğini çizelim.

Örnek 4:

A={-2,-1,0,1,2} olmak üzere $f: A \to \mathbb{R}$,f(x)=$2x^2$-1 fonksiyonunun grafiğini çizelim.

Örnek 5:

A={1,2,3,4} olmak üzere $f: A \to \mathbb{R}$,f(x)=-x^2+4 fonksiyonunun grafiğini çizelim.

Örnek 6:

$f: \mathbb{R} \to \mathbb{R}$,f(x)=x+2 fonksiyonunun grafiğini çizelim.

Örnek 7:

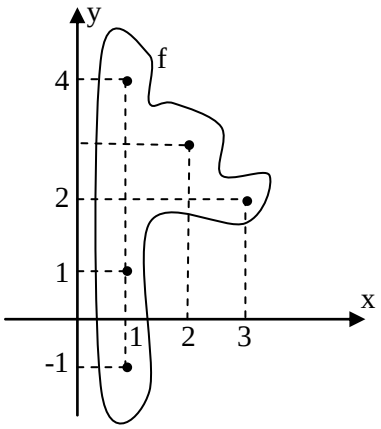
$f: \mathbb{R} \to \mathbb{R}$,f(x)=4x-2 fonksiyonunun grafiğini çizelim.

Örnek 8:

$f: \mathbb{R} \to \mathbb{R}$,f(x)=3x fonksiyonunun grafiğini çizelim.

Problem 24:

Yanda grafiği verilen f bağıntısının bir fonksiyon olup olmadığını grafiği inceleyerek açıklayınız.



Dikey Doğru Testi:

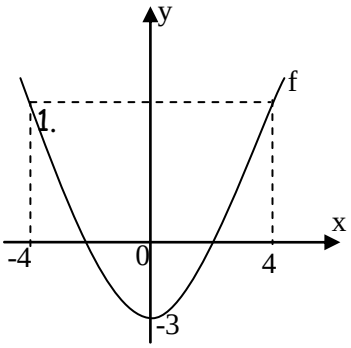
Bir bağıntının grafiği verildiğinde bu grafiğe ait bağıntının bir fonksiyon olup olmadığını anlamak için, x eksenine dik doğrular çizilir. Eğer *her* doğru grafiği sadece bir noktada kesiyorsa bu grafik bir fonksiyon grafiğidir. Eğer herhangibir doğru grafiği birden çok noktada kesiyorsa verilen grafik bir fonksiyon grafiği olamaz.

Çünkü;

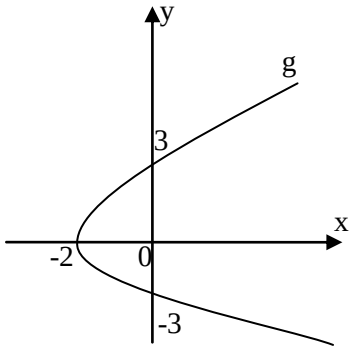
Alıştırmalar:

Aşağıda grafikleri verilen bağıntıardan onksiyon olanları belirtiniz.

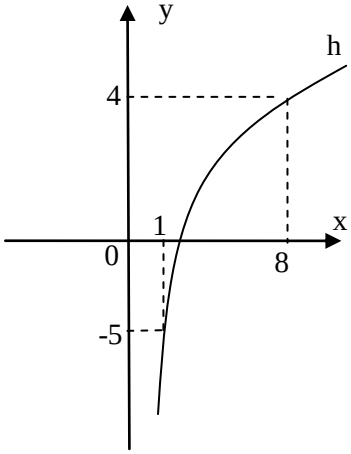
1.



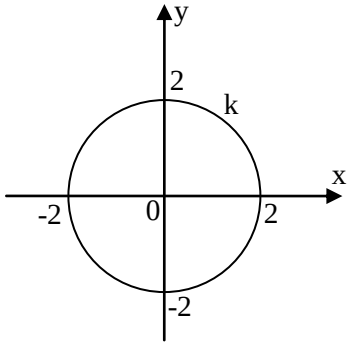
2.



3.

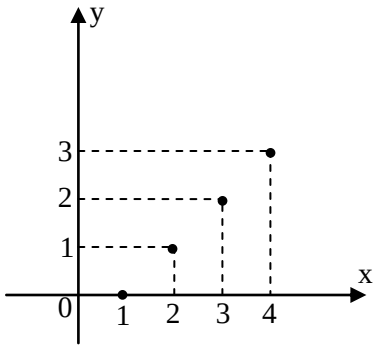


4.



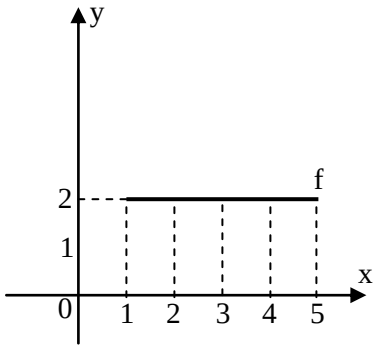
Problem 25:

Yandaki grafiğin hangi fonksiyonu belirttiğini tahmin ediniz ve bu fonksiyonun Tanım ve Görüntü kümelerini yazınız.



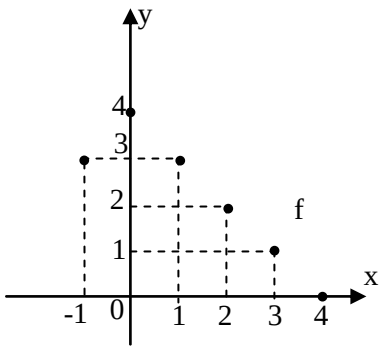
Alıştırmalar:

1. Yandaki grafiğin hangi kurala göre yazıldığını tahmin ediniz ve bulduklarınıza göre aşağıdaki soruları cevaplayınız.



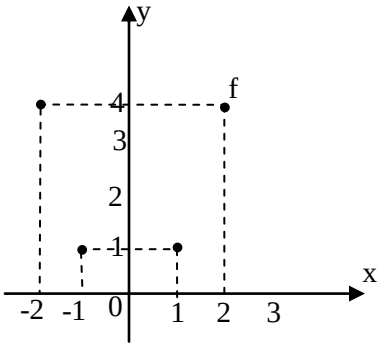
- f bir fonksiyon mudur?
- f nin tanım kümesini yazınız.
- f nin görüntü kümesini yazınız.
- f nin kuralını yazınız.

2. Yandaki grafiğin hangi kurala göre yazıldığını tahmin ediniz ve bulduklarınıza göre aşağıdaki soruları cevaplayınız.



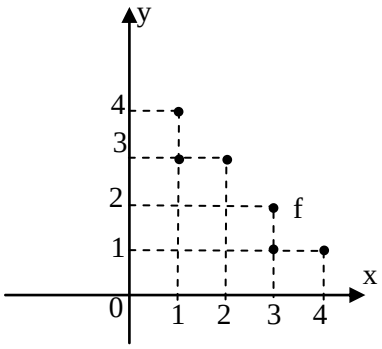
- f bir fonksiyon mudur?
- f nin tanım kümesini yazınız.
- f nin görüntü kümesini yazınız.
- f nin kuralını yazınız.

3. Yandaki grafiğin hangi kurala göre yazıldığını tahmin ediniz ve bulduklarınıza göre aşağıdaki soruları cevaplayınız.



- f bir fonksiyon mudur?
- f nin tanım kümesini yazınız.
- f nin görüntü kümesini yazınız.
- f nin kuralını yazınız.

4. Yandaki grafiğin hangi kurala göre yazıldığını tahmin ediniz ve bulduklarınıza göre aşağıdaki soruları cevaplayınız.



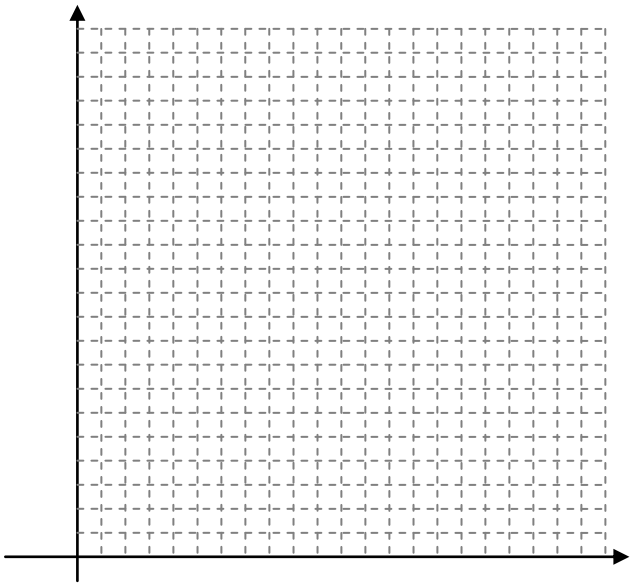
- f bir fonksiyon mudur?
- f nin tanım kümesini yazınız.
- f nin görüntü kümesini yazınız.
- f nin kuralını yazınız.

ETKİNLİK:

Kuzey yarı kürede ekinoks zamanları ve en uzun gece ve en uzun gündüzün yaşandığı zamanlar aşağıda verilmiştir.

21 Mart tarihinde gece ile gündüz süreleri eşitlenir.
21 Haziran tarihinde en uzun gündüz, en kısa gece yaşanır.
(Yaklaşık olarak 16 saat 50 dakika gündüz.)
23 Eylül tarihinde gece ile gündüz süreleri eşitlenir.
21 Aralık tarininde de en uzun gece, en kısa gündüz yaşanır.
(Yaklaşık olarak 16 saat 50 dakika gece.)

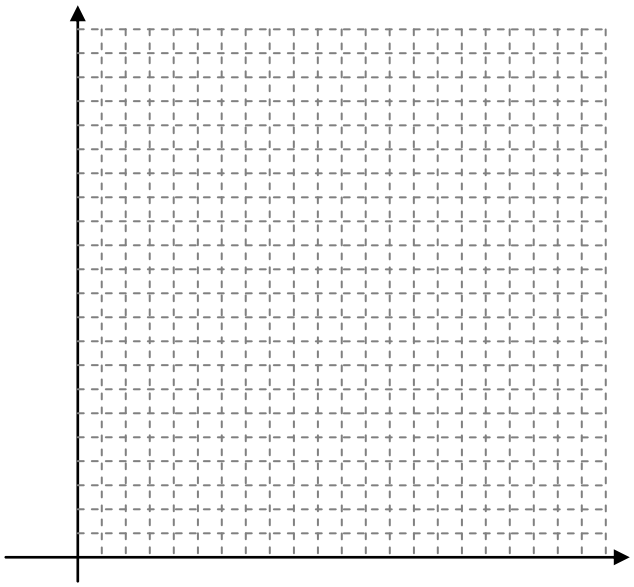
Buna göre belirtilen tarihleri grafikte işaretleyerek gece veya gündüz süreleri ile ilgili bir grafik çiziniz.



ETKİNLİK:

Aşağıda kifarg telefon şirketine bağlı olan Ayşe'nin telefon konuşmaları tablo halinde verilmiştir. Buna göre Ayşe'nin gün içinde Annesi, arkadaşı Gül, nişanlısı Mehmet ve kardeşi Ece ile telefon görüşmelerinin zamanlarını gösteren bir grafik çiziniz.

Aranan Kişi	Arama başlangıcı	Arama bitişi
Anne	10:00	10:30
Gül	14:00	14:20
Mehmet	16:10	17:00
Gül	17:30	18:00
Ece	20:00	21:00



Sorular:

1. Yukarıdaki tabloya göre kifarg telefon şirketinin tarifesi gereği (tarife aşağıda verilmiştir) Ayşe'nin bu günkü telefon konuşma tutarı kaç YTL olur?

Tarife:

- Her bir dakika için 2YKr
- Akşam 19:00 dan itibaren yarım tarife

2. Ayşe'ye bu gün için telefon şirketi 2,4YTL fatura kesmişse bu şirketin tarifesi nasıl olabilir?(Akşam için yarım tarife uygulaması olmak üzere)

Problem 26:

Aynı boyda , yanma süreleri ve kalınlıkları farklı iki mum için aşağıdaki bilgiler verilmiştir.

I. Kalın mum, her bir dakikada 15mm kısalmaktadır.
II. İnce mum, her bir dakikada 20mm kısalmaktadır.
III. İnce mum, 8 saat yanabilmektedir.

Buna göre her iki mum aynı anda yakıldıktan sonra 230. dakikada kalın mumun boyunun ince mumun boyuna oranı ne olur?

A

P

U

K

APPENDIX F

PROBLEM SOLVING STUDENT REPORT

PROBLEM ÇÖZME İÇİN ÖĞRENCİ RAPORU

ADI SOYADI:……SINIF……TARİH……..

DERS:……...

KONU:…….

PROBLEM:……
……
……
……
……..

Problem çözerken yaptıklarınızı ve hissettiklerinizi açıklamak için aşağıdaki soruları cevaplayınız.

1.Problemle uğraşmaya başladığında ilk defa ne yaptın?Ne düşündün?.....**.....**

……..

2.Problemi çözerken hangi aşamaya kadar gelebildin?Neden?.....

……...

3.Problemi çözerken hangi çözüm yolunu kullandın veya çalıştın?Neden?.....

……...

4.Problemi çözerken kullandığın veya kullanmaya çalıştığın yollardan başka problem çözmeye uygun yol var mı?Varsa bu yol nedir?.....**.....**

……
…….

5.Problem çözerken zorlukla karşılaştın mı?Bu zorluk nedir?.....

……
…….

6.Cevabın doğru olduğundan emin misin?Neden?.....

…….....

7.Cevabı kontrol etmenin önemli olduğunu düşünüyor musun?Neden?.....

……...

8.Problem çözümünü nasıl yaptığını açıklar mısın?.....

……..

……..

……..

……

9.Problem çözerken neler hissettiğini yazar mısın?.....

……
……

10.Problemi çözdüğünde ne hissettin? Neden?.....

……
……
……...

APPENDIX G

OBSERVATION FORM

SINIF İÇİ DERS GÖZLEM FORMU		
Derse başlama saati:	**Öğretmen:**	
Gözlem yapılan sınıf:	**Tarih:**	**Gözlemci:**
Konu:		

Ders hakkındaki düşünceler:	**Evet**	**Hayır**
1.Dersin başlangıcında öğrencilerin konuya dikkatleri çekildi.		
2. Ders işlenirken öğrencilere yeteri kadar söz verildi.		
3. Dersin işlenişi sırasında problemler ortaya atıldı.		
4. Problemlerin çözümünde problem çözme adımları kullanıldı.		
5. Problem çözme adımlarının kullanılması için öğrenciler teşvik edildi.		
6. Öğrenciler problem çözme stratejileri kullanmaları için motive edildi.		
7. Öğrencilerin derse katkıları değerlendirildi.		
8. Derste gerçek hayattan örnekler kullanıldı.		
9. Derste konunun gerçek hayatla ilgisi kuruldu.		
10.Derste kullanılan problemler öğrenci için ilgi çekici hale getirildi.		
11. Derste kullanılan sorulardan problem ve alıştırma olanları vurgulandı.		
12. Hemen hemen her öğrenci ile ilgilenildi.		
13. Dersin bitiminde konu toparlandı.		

Eklenmek istenen düşünceler: