

STUDENTS' LEARNING OF QUADRATIC EQUATIONS THROUGH USE OF  
INTERACTIVE WHITEBOARD AND GRAPHING SOFTWARE

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submitted by **MÜGE İNCE** 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**

Assist. Prof. Dr. Ayhan Kürşat ERBAŞ \_\_\_\_\_  
Supervisor, **Secondary Science and Mathematics Education Dept., METU**

**Examining Committee Members:**

Assoc. Dr. Behiye UBUZ \_\_\_\_\_  
Secondary Science and Mathematics Education Dept., METU

Assist. Prof. Dr. Ayhan Kürşat ERBAŞ \_\_\_\_\_  
Secondary Science and Mathematics Education Dept., METU

Assist. Prof. Dr. Erdiñ ÇAKIROĞLU \_\_\_\_\_  
Elementary Mathematics Education Dept., METU

Assist. Prof. Dr. Yeşim ÇAPA AYDIN \_\_\_\_\_  
Educational Sciences Dept., METU

Dr. Bülent ÇETİNKAYA \_\_\_\_\_  
Secondary Science and Mathematics Education Dept., METU

Date: 07.05.2008

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Signature:

## ABSTRACT

### STUDENTS' LEARNING OF QUADRATIC EQUATIONS THROUGH USE OF INTERACTIVE WHITEBOARD AND GRAPHING SOFTWARE

İnce, Müge

M:S:, Department of Secondary Science and Mathematics Education  
Supervisor: Assist. Prof. Dr. Ayhan Kürşat Erbaş

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The aim of this study was to investigate the effects of using interactive whiteboard and computer technology on graduate language and mathematics student' performance in quadratic equation functions graphics. Two groups of language and mathematics graduate students were selected for the study; one for experimental group and the other for control group. The experimental group consists of 32 students, and control group consists of 33 students. The control group is thought by traditional learning whereas the experimental group is thought the same topic by interactive whiteboard and computer technology. Graphic Achievement Test (GAT), Attitudes toward Technology Scale (ATTS) and Attitude toward Mathematics Scale (ATMS) and interviews were used as a data collection instruments. GAT applied as a pre-test, post-test and delayed post-test on both of the groups. However the attitudes scales applied only experimental group before and after the treatment.

**Keywords:** Interactive Whiteboard, Computer Technology, Quadratic Equations Graphics

## ÖZ

### İNERAKTİF TAHTA VE GRAFİK YAZILIMI KULLANIMIYLA ÖĞRENCİLERİN KUADRATİK DENKLEM ÖĞRENMESİ

İnce, Müge

Yüksek Lisans, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü  
Tez Yöneticisi: Yard. Doç. Dr. Ayhan Kürşat Erbaş

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Bu çalışmanın amacı, interaktif tahta ve bilgisayar teknolojisinin ikinci derece denklem grafikleri konusundaki Türkçe-Matematik branşı mezun öğrenciler üzerindeki etkisini ölçmektir. İki grup Türkçe-Matematik branşı öğrencileri deney ve kontrol grubu olarak seçilmiştir. Deney grubu 32 ve kontrol grubu 33 öğrenciden oluşmaktadır. Kontrol grubu geleneksel eğitim metodu ile konuyu öğrenirken, deney grubu aynı konuyu interaktif tahta ve bilgisayar ile öğrenmiştir. Grafik Başarı Testi, Bilgisayarlı Eğitime Karşı Tutum Ölçeği, Matematiğe Karşı Tutum ölçeği ve röportajlar veri toplamak için araç olarak kullanılmıştır. Grafik başarı testi ön test, son test ve gecikmeli son test olarak her iki gruba da uygulanmıştır. Tutum ölçekleri ise sadece deney grubuna eğitim öncesinde ve sonrasında uygulanmıştır.

**Anahtar Kelimeler:** İnteraktif Tahta, Bilgisayar Teknolojisi, İkinci Derece Denklemlerin Grafikleri

Dedicated to Çađrı Kaya and the family of İnce

## TABLE OF CONTENTS

ABSTRACT.....	iv
ÖZ.....	v
TABLE OF CONTENTS.....	vii
LIST OF TABLES.....	ix
LIST OF FIGURES.....	xi
LIST OF ABBREVIATIONS.....	xii
CHAPTERS	
1. INTRODUCTION.....	1
1.1 Research Problem .....	4
1.2 Significance of the study .....	4
1.3 Definitions of the terms.....	5
1.4 Limitations.....	7
2. REVIEW OF LITERATURE.....	8
2.1 Importance of teaching graphics.....	8
2.2 Task involved interpretation and construction of graphics.....	9
2.3 Students Difficulties in Learning Graphics Concept .....	10
2.4 Teaching with Technology.....	11
2.4.1 Computer and Graphing Calculator Technology in Graphing Concept.....	12
2.4.2 IWB Technology in Teaching .....	14
2.4.2.1 IWB Use in Mathematics Lessons.....	16
3. RESEARCH DESIGN AND METHODOLOGY.....	17
3.1 Sample.....	17
3.2 Procedure.....	18

3.3 Instruments.....	21
3.3.1 Graphic Achievement Test (GAT).....	21
3.3.2 Attitudes towards Mathematics Scale (ATMS).....	24
3.3.3 Attitudes toward Technology Scale (ATTS) .....	24
3.3.4 Interview with students.....	25
3.4 Treatment Procedure.....	27
3.4.1 Treatment in the Experimental Groups.....	29
3.4.2 Treatment in the Control Groups.....	33
3.5 Pilot Study.....	34
4. RESULTS.....	36
4.1 Descriptive statistics: .....	36
4.2 Inferential Statistics.....	40
4.3 Qualitative Data Analyses .....	43
4.3.1 Qualitative and Quantitative Results of the GAT.....	43
4.3.2 Results of the interview.....	72
4.3.2.1 Students View About the graphic concept.....	72
4.3.2.2 Students View About the IWB.....	74
4.3.2.3 Studnets View About the Computer .....	75
5. DISCUSSION, CONCLUSION AND IMPLICATIONS.....	77
5.1 Students' Performance in Graphics.....	77
5.2 Students' Attitudes toward IWB and Computer .....	79
REFERENCES.....	81
APPENDICES	
A. GRAPHIC ACHIEVEMENT TEST (GAT).....	86
B. ATTITUDE TOWARD MATHEMATICS SCALE (ATMS).....	102
C. ATTITUDE TOWARDTECHNOLOGY SCALE (ATTS).....	104



## LIST OF TABLES

### TABLES

Table 3.1 Content of GAT .....	22
Table 3.2 Objectives for each lesson.....	27
Table 4.1 Descriptive statistics related to the scores from GAT as pre-test, post-test and delayed-post test, for experimental (N=32) and control group (N=33).....	36
Table 4.2 Descriptive statistics related to the scores from ATMS and ATTS for experimental group (N=32).....	38
Table 4.3 Frequencies and percentages of ATTS item.....	39
Table 4.4 Levene's test for equality of variances for POSTGAT scores.....	40
Table 4.5 Result of the ANCOVA for POSTGAT.....	41
Table 4.6 Result of the Levene's test for DPGAT.....	41
Table 4.7 Result of the ANOVA for DPGAT.....	42
Table 4.8 Frequencies and percentages f (%) for the first sub-item in the PREGAT, POSTGAT and DPGAT.....	43
Table 4.9 Frequencies and percentages for the second sub-item in the PREGAT, POSTGAT and DPGAT.....	45
Table 4.10 Frequencies and percentages for the third sub-item in the PREGAT, POSTGAT and DPG.....	46

Table 4.11 Frequencies and percentages for the fourth sub-question in the PREGAT, POSTGAT and DPGAT.....	47
Table 4.12 Frequencies and percentages for the second item in the PREGAT, POSTGAT and DPGAT.....	52
Table 4.13 Frequencies and percentages for the third item in the PREGAT, POSTGAT and DPGAT.....	53
Table 4.14 Frequencies and percentages for the fourth item in the PREGAT, POSTGAT and DPGAT.....	56
Table 4.15 Frequencies and percentages for the fourth item in the PREGAT, POSTGAT and DPGAT.....	57
Table 4.16 Frequencies and percentages for the seventh item in the PREGAT, POSTGAT and DPGAT.....	61
Table 4.17 Frequencies and percentages for the eighth item in the PREGAT, POSTGAT and DPGAT.....	61
Table 4.18 Frequencies and percentages for the ninth item in the PREGAT, POSTGAT and DPGAT.....	65
Table 4.19 Frequencies and percentages for the tenth item in the PREGAT, POSTGAT and DPGAT .....	66
Table 4.20 Frequencies and percentages for the eleventh item in the PREGAT, POSTGAT and DPGAT.....	67
Table 4.21 Frequencies and percentages for the twelfth item in the PREGAT, POSTGAT and DPGAT .....	68

## LIST OF FIGURES

### FIGURES

Figure 3.1 The screen shot of the computer.....	19
Figure 3.2 Classroom environment in the experiment group.....	30
Figure 3.2. Laboratory environment for the experimental group.....	31
Figure 4.1 Multiple line graph showing the control and experimental groups mean scores from pre-test, post-test and delayed post-test.....	37
Figure 4.2 Students' responses for the item one in pre-test.....	49
Figure 4.3 Students' responses for the item one on the post-test.....	51
Figure 4.4 Students' responses for item three in the post-test.....	55
Figure 4.5 Students' responses for item fourth and fifth.....	58
Figure 4.6 Students' responses for item seven and eight.....	63
Figure 4.7 Students' responses for the item thirteen and fourteen.....	70

## LIST OF ABBREVIATIONS

IWB	: Interactive whiteboard
CG	: Control Group
EG	: Experimental Group
GAT	: Graphic Achievement Test
ATTS	: Attitude Toward Technology Scale
ATMS	: Attitude Toward Mathematics Scale
N	: Sample Size
Mdn	: Median
SD	: Standard deviation
K-R 20	: Kuder-Richardson formula
p	: Significance Value
df	:degree of freedom

# CHAPTER 1

## INTRODUCTION

Visualization is very important in learning and teaching of mathematics and the concept of graphics is considered by many teachers, researchers to be the most important and fundamental concept in all of mathematics. (Doerr & Zangor 2000; Leinhardt, Zaslavsky & Stein, 1990; Mevarech & Kramarsky 1997). The reasons why graphics are so important are that they are essential for the algebra curriculum and can be used as a bridge between concrete thinking and abstract thinking (Piaget, Grize, Szeminska & Bang 1977). Moreover graphics provide assistance in solving arithmetic and algebraic problems and represent relationships among variables. Also they are the link between high level mathematics and daily life application. (Ateş & Stevens 2003; Kramarski, 1999). As a daily life application; graphics, especially parabolas are seen in satellite dishes, automobile headlights, telescopes and computer games, parabolic microphones used at football games and construction of bridges.

Understanding the principles and interpretations of graphics are also important for learning other areas such as natural and applied sciences. As emphasized by Lake and Kramp (2002) study of graphics is an area of mathematics that would satisfy both the integration of mathematics into other learning areas and the integration of other areas into mathematics.

Concerning the NCTM (National Council of Mathematics Teacher, 2000) standards, high school students should have knowledge about properties of functions. They are expected to interpret representations of functions of two variables, to understand properties of graphics and their corresponding equations. For instance, they should learn that the function  $f(x) = x^2 - 2x - 3$  is quadratic, that

its graphics is parabola and opens "up" because of positive leading coefficient and its graphics cross the y-axis on -3. Besides these, they should also expect to learn how to find the roots of quadratic functions and the interpretation of the roots on graphics. For example, some quadratic equations do not have real roots and this characteristic corresponds to the fact that their graphics do not cross the  $x$ -axis. So, students are expected to know parabola, how to draw its graphics, how change in coefficients affect the shape of the parabola, whether the graphics cross the axis or not and the reasons, find its peak point and symmetry axis. Moreover, they should perform translations, such as adding 2 units on the  $x$ -axis or  $y$ -axis for the given parabola without calculation or changing the leading coefficient as the opposite sign. To learn things mentioned above such as the way coefficients shape the graphics or transformation can be done by utilizing computer or calculator that carries out manipulations of symbolic expressions or equations, can compute or approximate values of functions or solutions to equations, and can plot functions and relations. With the help of such technologies, students can easily explore the effects of changes in parameters and the transformation of given function with better understanding of graphics (NCTM, 2000).

As emphasized by the NCTM, in order to have a better understanding of graphics students can benefit from the technology. Technology is essential in teaching and learning mathematics since it influences teaching of mathematics and enhances students' learning (NCTM). And also, technology plays a unique role in facilitating students' graphing skills, and in understanding of graphical representations. For learning and applying mathematics, technology in the form of 'mathematics analysis tools' (such as certain computer software, calculators, graphic calculators, computer algebra systems, spreadsheets) can assist students' problem solving skills, support exploration of mathematical concepts, provide dynamically linked presentations of ideas and encourage general metacognition abilities (Forster, 2006; Barkatsas, Pierce & Stacey, 2007).

Technology has allowed much more emphasis to be placed on graphics and their interpretation, both to help students understand key ideas and to deal with practical algebraic problems. They offer many advantages over manual graphics plotting,

such as multiple representations, and also they allow students to examine many more graphics quicker with a high degree of accuracy, and with minimal input effort (Fung, Hennessy & Scanlon, 2001). By using technology, students investigate graphics, check their answers, zoom in and out, scale the given function, and find interception points. Moreover, Texas Instrument (2003) conclude that, with graphing calculators, students plot the graphics and then observe its patterns and make connections among algebraic, tabular and graphical representations with high accuracy in shorter time comparing to manual plotting of graphics. Beside all these, with the use of technology, students find a chance to discover the translations of functions, the changes in the shape of the graphics with changing coefficients (Berry, Graham & Smith, 2006). By studying graphics with technology, students' understanding of concept and their achievement increase, their solution strategies develop, the time spent on plotting graphics takes less time and such time is spent on more discussion, on translations of graphics, and on changing shape of graphics by coefficients (Harskamp, Suhre & Van Streun, 2000, Schwarz & Hershkowitz, 1999).

Technology for teaching and learning graphics is not limited with computers and graphing calculators. One of the technologies that emerge recently for learning and teaching is interactive whiteboard (IWB). An IWB can be thought of as a mixture of a computer, an overhead projector and a whiteboard (chalkboard) (Gage, 2006). Since IWB is a computer, all the computer properties can be used such that IWB turns a computer into a powerful teaching and learning device with the use of vivid colors, different fonts, integrated web pages and applets, presentation software and scanned images (Fernandez & Luftglass, 2003).

Evidence suggests that use of IWB can have positive effects on teaching and learning (British Educational Communications and technology Agency (BECTA), 2003). Glover and Miller have shown that usage of IWB promotes students interests, provides longer sustained concentration, and more effective learning. IWB also foster responses to a range of learning process (Glover & Miller, 2001; Averis, Glover & Miller, 2007).

## **1.1 Research Problem**

The purpose of this study was to examine the effect of technology supported environment on graduate art and mathematics branch students' attitudes toward and achievement on understanding of quadratic equations graphics; parabola. Therefore the related research questions are;

- 1 Are there any significant difference between control group and experimental group students with respect to their post graphic achievement score after controlling for their pretest scores?
- 2 Are there any significant difference between control group and experimental group students with respect to their delayed post graphic achievement scores?
- 3 Are there any significant differences in the attitude scale toward mathematics test (ATMS) scores of the experimental group students before and after the treatment on graphics?
- 4 Are there any significant differences in the attitude scale toward technology test (ATTS) scores of the experimental group students before and after the treatment on graphics?
- 5 What are the experiment and control group students' solution strategies in the graphic achievement test?
- 6 What are the student's attitudes towards interactive whiteboard and computer environment?
- 7 What are the students' opinions about interactive whiteboard and computer based learning?

## **1.2 Significance of the Study:**

This study provides information about the use of interactive whiteboard. The IWB takes the place of whiteboard (chalkboard) and it is a new technology in education (Greiffenhagen, 2000). Consequently, the available literature is limited to a number of reports and summaries of small-scale research projects undertaken by individual teachers, schools and higher education institutions. The current limited research emphasize mostly how to use this new device (Averis, Glover, & Miller, 2005; Shae & Tseng ,2005), teacher use of IWB (Beauchamp, 2004;



Beauchamp & Kennewell, 2007), the pedagogy of using IWB, students attitudes, interaction between students, teacher and technology (Armstrong, Barnes, Sutherland, Curran, Mills & Thompson, 2005; Hardman & Higgins, 2005). Also the researchers apply surveys on teachers and school principals and mostly make interviews with teachers. Moreover literature is limited as the studies have been carried out mostly on primary and secondary grades. For example Wall, Higgins and Smith (2005) investigated the students view about IWB with students at age 6-7.

As seen, literature does not emphasize how IWB affects students' attitudes toward technology in mathematics lessons and how their achievement is affected by this new technology. So this study use IWB in the teaching process and give an idea concerning the students' side. Moreover not only the IWB is used as a technology tool. After the lessons, computer laboratories take place. So that students have a chance to apply what they learn with IWB. Both technology; IWB and computer are used as a part of the lesson.

There is considerably less data on the effects of computer-aided graphing and most of it comes from studies conducted in United States (Barton 1997). Since each country has different culture and attitudes toward lessons, therefore it is also important to assess whether such technology is appropriate for Turkey.

So, this study investigates the students' attitudes towards IWB and computer instruction along with its affects in students' performance on graphics and students' retention. So the emphasis is on the impact on students learning and attitudes. Understanding students' performance differences and analyzing their work may contribute to having a better understanding on this issue.

### **1.3 Definition of Terms:**

**Interactive whiteboard:** an interactive whiteboard is a large, touch sensitive board which is connected to a digital projector and a computer. The projector displays the image from the computer screen on the board. The computer can then be controlled by touching the board, either directly or with a special pen. IWB has everything that a computer has; internet, office applications, any computer programs and also every document can be saved and printed. Also IWB can be used as whiteboard with endless clean pages. Moreover these clean pages can be obtained by one click on the board with having the previous pages. The previous pages still be available on the board and just one tab or click the previous pages can be seen. The background color and design can be changed and these background designs include lines, square grids, and graphic paper. Also different colors of pen can be used on the board (BECTA, 2003; Gage, 2006). However, Glover and Miller (2001) defined interactive whiteboard (IWB) as follows: “Theoretically, the interactive whiteboard is more than a computer, a projector or a screen. Its sum is greater than its parts, and when all the technology is turned off the board surface can be used as a conventional dry-wipe whiteboard”.

**Computer based learning:** Using computers as a tool for practicing what the students learn in the lessons. The interaction between a learner and a computer is based on a symbolic interpretation and computation of the learner input, and the feedback.

**Traditional instruction:** A teaching style that the teacher is at the center of the lesson and students follow the lecture with paper-pencil activities. Students are responsible for listening to the lessons, taking notes, answering and solving questions that teacher asks.

**Dersane:** Private education institutions that prepare students for the nationwide standardized exams such as University Entrance Examination (ÖSS) and Student Selection and Placement Exam for Secondary Education Institutions (OKS).

Students are prepared for the OSS in mainly three branches: art branch, science branch and art and mathematics branch.

#### **1.4 Limitations**

1. The representative sample will include only two classes (of approximately thirty-two students each).
2. The researcher will be the teacher of both experimental and control group. Therefore the researcher bias may affect the outcomes.
3. This study will address the graphics concept on quadratic functions, particularly parabolas.
4. The time for the treatment takes two week and this limited time may affect students' attitudes toward technology and lessons.

## **CHAPTER 2**

### **REVIEW OF LITERATURE**

In this chapter, the importance of graphics, required and involved tasks in graphics and student difficulties with plotting will be reviewed. Also, usage of technology in mathematics and graphics concept (especially computer and IWB) will be reviewed after subjects mentioned above.

#### **2.1 Importance of Teaching Graphics**

Graphing is considered as a fundamental and important part of mathematics and science curriculum (Callaghan 1998; Doerr & Zangor 2000; Kramarsky & Mevarech, 1997; Leinhardt, Zaslavsky & Stein1990; Michael & Michael M. 2003). The reasons for these are that graphics can summarize very complex information or relationship very effectively and students need graphics to represent and interpret relationships (Koca, 2001). The skill to predict relationships between variables and to explain these relationships takes place in science curriculum more than any other subjects and graphics construction is an integral part of experimentation. Such comments lead to the idea of graphics and graphing skills are important for students not only for mathematics but also for science lessons (Ateş& Stevens, 2003; Kemp 2001). Another reason for the importance of graphics is that graphics are the fundamental part in mathematics and, it is a bridge between concrete and abstract thinking because graphics and graphics construction involves solving arithmetic and algebraic problems and representation of variables (Piaget, Grize, Szeminska & Bang1977).

In order to draw and interpret graphics, students need to apply, select and transfer among mathematical representations. The representation consist of three

part; algebraic, tabular (numeric) and graphical (Cunnigham, 2005). Students need to pass between these representations to solve problems. Therefore, graphics concept include multiple and linked representations.

Besides all these, graphics is a link between high level mathematics and daily life (Ateş & Stevens 2003; Kramarski, 1999). The graphic knowledge is required to build a bridge. When the main (curved) cables are attached to the deck by vertical cables they will end up in the shape of a parabola In order to find cable length students need to find the right quadratic format which is parabola (Newkirk). Moreover satellite dishes, automobile headlights; telescopes are examples where the parabola problems are seen.

## **2.2 Task involved interpretation and construction of graphics**

Students need some skills, tasks and knowledge in order to draw graphics. They need to understand the meaning of variables, know the principles of Cartesian system, and understand transformation processes between verbal, algebraic, and graphical representations (Kramarski, 1999). Also, Leinhardt, Zaslavsky, Stein (1990) classifies four tasks in order to interpret and construct graphics:

- prediction tasks
- classification tasks
- translation tasks
- scaling tasks

**Prediction task:** Students are expected to predict the missing parts of the graphics from the given parts. Without having the equation they expected to continue to graphics by detecting the pattern. Some prediction tasks rely primarily on estimation and to some extent on measurement skills. (Leinhardt, Zaslavsky, Stein 1990). Also prediction task involves predicting the shape of the graphics from its degree; first degree is a straight line, second degree is a parabola.

**Classification task:** The students identify whether the given shape or equation is a function or not. Students are expected to recognize the required functions among

others. Given a set of functions in algebraic forms (i.e., symbolically), students are asked to find the graphics of the functions either by looking at the coefficients of the symbolical form or by using properties of quadratic functions (e.g., finding the discriminate and determining whether the graphics cross the x axis or not) or by drawing the graphics of the symbolic form. Students are also expected to decide how coefficients affect the graphics. To illustrate, the quadratic equation graphics; parabola in the form of  $ax^2+bx+c$ , the coefficient of “a” decide whether the parabola is upward or downward, the “c” defines where the parabola crosses the y-axis,  $-b/2a$  defines the symmetry axis for parabola. So students need to predict the shape of a given function, intercept points, symmetry axis of parabola.

**Translation task:** There are three forms of functions; algebraic ( $y=ax^2+bx+c$ ), tabular (constructing table according to x and y pairs) and graphical (shape of the function in the Cartesian coordinate system). Students are expected to recognize and translate the given function in these three different representation forms. Moreover, students are expected to construct required representation from the given representation.

**Scaling task:** “Scale refers to the assignment of values to intervals between the lines on the Cartesian system”(Leinhardt, Zaslavsky & Stein, 1990). In the scaling task, students make decision about the scaling of the axes; they need to pay attention to the units on x and y values. In the graphics problems, sometimes the axes are not labeled or only the integers are given and students are expected to find where the graphics crosses the axes. Also sometimes unequal scales for the x-axis and y-axis are given and students are expected to realize these unequal scales.

### **2.3 Students Difficulties in Learning Graphics Concept:**

The major difficulty for the students of all ages is the translation between algebraic, graphical and tabular representations. Students find it very hard to understand relationship and translate among representations because each representation and translation among them requires different psychological process (Leinhardt, Zaslavsky & Stein, 1990). For example, mostly in the problems,

translations from equation to graphics and from graphics to equation are required. Concerning these two translations, movement from graphics to their equation would be a more difficult task because it involves pattern detection. On the other hand, graphing an equation consists of steps; finding ordered pairs, plotting them on coordinate system and drawing the equation. If the question is about drawing graphics from the algebraic form, students follow the steps mentioned before, and draw the graphics but if the question involves giving the parabola and finding the equation students have more difficulty and if this is an item matching question students check for the equations, do not attempt to move graphics to equation.

Students' habits of drawing linear equations cause some wrong drawings on quadratic equations. Students need at least two paired points to draw the graphics of linear equations however the quadratic equations require more information to draw its graphics. So students find two points and draw the parabola like linear equation. Furthermore, some students use these two points to find the slope value of a parabola or take the leading coefficient as slope.

Another difficulty with graphics is scaling task. The graphics in textbooks usually have equal scales and critical points of the equation ( $x$ - $y$  intercept, axis of symmetry) are usually integer. However, in the problems, students faced with unequal scales and rational or decimal critical points and students find it difficult to interpreting their results on the graphics. Also partial views, axis without labels, individual points on the graphics other difficulties for students to interpret. But with utilization of graphing technologies students are forced to think about such issues, since it may give the equation with or without the scale, or even with partial view (Cavanagh & Mitchelmore, 2003; Leinhardt, Zaslavsky & Stein, 1990).

## **2.4 Teaching with Technology**

Mathematics education has undergone a great change because of technological developments. When studies are analyzed, the positive effect of technologies (computer, computer algebra systems, interactive white boards and graphing calculators) can be concluded. To illustrate, Abrahamson, Roschelle and Penuel

(2004), found that students actively involved in the lessons, their interest and achievement increase with complex subject matter with the help of technology use. Also Hannafini and Land, 1997, find similar result, they showed that technology provides interactive learning that increases students' learning and interest, deepen their understanding, and enrich their thoughts. Moreover other researches emphasize another advantage of using technology that technological environment supports visualization and experimentation (Arcavi & Hadas, 2000). Visualization refers to ability to represent, transform, generate, communicate, document, and reflect on visual information and experimentation refers to getting many examples, look for extreme cases, negative examples ,measuring, comparing, changing figures.

As stated by NCTM “technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning”. Students' engagement with abstract mathematical ideas can be fostered through technology. Technology enriches the range and quality of investigations by providing a means of viewing mathematical ideas from multiple perspectives (NCTM, 2000).

Therefore concerning all these; one of the exciting potential of technology is the affect on increasing the conceptual understanding and reasoning on students. And the technology can be used to increase the interest and motivation of the students toward the lessons. With technology based lessons, students can make connections and construct their own knowledge causing the increase in attitudes and achievement.

#### **2.4.1 Computer and Graphing Calculator Technology in Graphing Concept**

In recent years technology usage in the form of a computer and graphing calculator increased in mathematics lessons (Anderson, Bloom, Mueller & Pedler 1999; Forster 2006; Graham& Thomas, 2000). With these technological tools, students can draw and manipulate graphics on screen where graphical, tabular and symbolic representations are displayed. Also, changes can be observed by students immediately. Moreover, drawing more than one graphics on the same screen



provide coordinating multiple representations of graphics so that relationships and properties of graphics can be observed and discovered by students. Quick accurate numerical calculations, production of graphics and symbolic processing on computer have been shown to be valuable for mathematics learning (Foster 2006; Kordaki & Potari 2002). Moreover, Heid, (1995), summarized the benefits of graphing tools as they allows ready visualization of relationships, promote exploration by students and their understanding of the effect of change increase in one representation on another representation and they encourage the exploration of relationships and mathematical concept.

Besides these researches, there are varieties of researches conducted so as to explain the effectiveness of graphing technology and to explain the students' attitudes toward technology with different age groups. To illustrate, Barton (1997) made activities about extracting data from graphics, sketching graphics making predictions about graphics to investigate the effect of the computer on graphical interpretation skills. To investigate that he had 36 students coming from different schools with ages of 8-10 in the control and experiment groups. He observed that students in both groups did not react equivalently, the experimental group made more connections with their previous knowledge compared with the control group. Also he concluded that manual graphics plotting is a problem for all of the students and real-time plotting on the computer screen stimulates students to provide explanations and to make predictions.

Also another study, Doerr and Zangor (2000), shows how students use graphing calculators. They were observed 31 students aged 15-17 to understand how students used graphing calculators in support of their learning of mathematics. The students asked to interpret data, to find meaningful representations of the data (tables, graphics and equations), and to generalize relationships. They found that students use graphing calculators as a transformational tool, data collection and analysis tool, visualizing tool and as a checking tool. Like Doerr and Zangor also Hennessy, Fung and Scanlon (2001) investigate graphics recognition and interpretation skills, how these skills developed through exploring different kinds

of graphics with different age groups. They conduct their research on university entry level course and the participants use TI-80. Especially they emphasize the translation task; tabular, graphic and algebraic representation of function. They use a questionnaire to investigate students' attitudes for graphing calculators. The response of 48 students showed that %85 of students developed a positive feeling and attitudes after using the graphing calculator. And many students emphasize that their self-confident increased with the calculator use. But more importantly students showed that the graphing calculator positively altered the attitudes toward mathematics. They find doing mathematics more enjoyable (%85) and easier (%78). Moreover, students mostly mention about the visualization (n=12), speed (graphing, equations, calculus and calculations were much quicker or immediate, making mathematics more efficient and more time for investigation (n=11), overcoming the difficulties compared to manual drawing (n=5) and immediate feedback and response to changes in equations; automatic translation between representations (n=9).

Concerning all these, graphing technology in the form of a graphing calculator and computer was determined to be the central reason for students' improvement in three areas: understanding of graphical concept, the ability to make meaningful connections between functions and their graphics, and enhanced spatial visualization skills (Ellington, 2003). Since these technologies allow students visual representations of functions, speed up the process, emphasis translation task, give immediate feedback, generates more than one graphics at one time in one coordinate system so support multiple representations.

#### **2.4.2 IWB Technology in Teaching**

Research suggests that IWB does not naturally cause an increase in learning. In the early stage of teaching, IWB can be used as a blackboard without having any interactivity if the teachers do not have enough experience and training (Tanner & Jones 2007). However after enough experience and training, the IWB increase and retain students' attention. With the use of the IWB in the lessons concentration, motivation and attention of students are increased. Wood and Ashfield in 2007

found that the students' interest, motivation and attention increased since students are looking at something colorful and bright.

Evidences suggest that use of IWB may have positive effects on teaching, learning and attitudes toward lessons. The reason for IWB to support learning and teaching is that, the IWB motivates the students due to its capacity for quality presentation by incorporating large visual images and variety of learning styles. Students show more interest, more sustained concentration, more effective learning. Moreover, the IWB is beneficial for the teachers since it encourages spontaneity and flexibility, allowing teachers to draw on and annotate a wide range of web-based resources and also allows teachers to share and re-use materials, reducing workloads. (Glover & Miller, 2001; Beaucamp, 2004; Armstrong, Barnes, Sutherland, Curran, Mills & Thompson, 2005; Wall, Higgins and Smith & 2005; Gage 2006; Glover, Miller, Averis & Door 2007; BECTA 2007).

Glover and Miller in 2001 examined the students and the teachers that used IWB in the lessons. The researchers used a questionnaire on 46 staff and 750 students' age between 11 and 16. The questionnaires consisted of likert type questions and yes-no questions. Also 14 staff and 18 students were interviewed. Questionnaire evidence indicates that improved presentation is the most frequent result of the technology. In case of motivation, they found that the IWB motivates students by cool image (%12) and mostly (%60 of students) motivates by the use of good software programs and high quality presentations. In the interviews, the students emphasized that the lessons with IWB were usually much more easy to follow and easy to go back and repeat over if students need, could often help those who were having difficulty in understanding. Also the head of the faculty of mathematics concluded that "students learn quicker because they follow the arguments set out by teacher".

Tate in 2001 found similar results. Four section of k-12 classes; two for control (n=68) and two for experimental group (n=66) were used to search students in the IWB classroom. The results show more interest and enthusiasm in the course and

as a result the retention rate increases in the experimental group. She found that the retention rate increased with 97,1% in the experimental group. Also students in the experimental group show more positive attitude than in control group.

#### **2.4.2.1 IWB Use in Mathematics Lessons**

Mathematics and especially geometry requires visualization. When geometric terms, pictures, and concepts, along with charts and graphics are displayed and manipulated on the IWB, it gathers students' interest and curiosity while promoting a greater depth of understanding (Ball, 2003). Glover, Miller and Averis mentioned the same conclusions as Ball in 2005. Students' level of interest and understanding has been increased while using the IWB in the classroom because of the interactive, visual nature of the board. As students' learning is enhanced, their self-esteem and sense of achievement regarding mathematics increased (Richardson, 2002).

Moreover, the concept of rotation, translation, reflection can be thought by the interactive whiteboard more effectively (Robinson, 2004). Robinson worked with 61 seventh grade students. Pre-test and post- test designs are implemented in the study and these are followed by interviews. The control group had no access to the IWB and the experimental class was taught with IWB. In the control group, one student got the same score on pre-test and post-test while the others increased their scores. In the experiment class, two students scored the same on both the pre-test and post- test, while all other students increased their score. However in the interviews students reported that; they were more interested and paid more attention in their mathematics class when the IWB was used during their classes, and the students felt they understood the mathematics to a greater degree, causing them to "like" mathematics more (have greater positive attitudes towards teaching and learning of mathematics) when the interactive electronic whiteboard was being used in their class. He did not find any significant mean score difference between experimental and control groups, but the experimental group showed more positive attitude toward the mathematics lessons when the IWB used. So he concluded that IWB has no significant affect on achievement but increases the attitudes toward the lesson.

## CHAPTER 3

### RESEARCH DESIGN AND METHODOLOGY

This is a qualitative and quantitative research study to examine quadratic functions graphics. The design and methodology will be explained in this chapter with the following order; first of all the sample, procedure of the study and then the instruments and treatments for the control and experiment group will be given. And finally, the settings will be given.

#### 3.1 Sample

The students selected for the experiment and control groups of the study are high school graduate students from two different dersanes in Ankara. The students are responsible for algebra, geometry, Turkish language, history, geography and philosophy subjects at ÖSS (University Entrance Examination). The students in both groups were chosen considering their ÖSS scores from previous years and high school grades. The students who participate in the study are average students considering their high school grades and ÖSS scores. The experiment group consists of 32 (11 male and 21 female) students whereas the control group consists of 33 (13 male and 20 female) students. Although the number of the students at the beginning of the study was 35 for both the experiment and control groups, numbers of students of each group are defined by the students who complete the treatments and all of the tests.

The students' ages in both groups ranged from 18 to 20. The study took place at two different dersanes. Therefore students in experiment and control groups did not know and see each other and did not have a chance to interact with each other. Moreover students' social and economic statuses were nearly the same. Except for two families in the control group, only one family member had a job and their salaries were nearly the same (their income range between 800-1100 ytl per

month) in both groups. And also none of the students had a computer at home. The experiment group took the lessons in one of the dersane that had interactive whiteboard (IWB) in the classroom and also had computer laboratory with sixteen computers. One of the computers is for the teacher and it is connected to a TV screen. The screen is placed in front of the computers so that every student has a chance to see teacher's screen with large size and detail. Teacher's actions in main computer can be seen on this screen. The IWB is available for every lesson and at any time like computer laboratory. Whereas the control group took their lesson in another dersane in Ankara that had blackboard to teach the subject and do not have computer access. However classroom conditions are similar for both groups; class size and classroom belongings (like seats, desks and etc.) other than IWB and laboratory are same for each place.

Both experiment and control group students are taught by the researcher. The lessons and assignments were prepared by the researcher concerning MEB standards and objectives. After preparing assignments and lessons, two other mathematics teachers' opinions were taken as one is 35 years old with 10 years teaching experience and the other is 37 years old with 12 year teaching experience. The assignments levels are determined by the students' success from their high school mathematics scores and scores from their exams in dersane.

### **3.2 Procedure**

Research data were collected over a period of two weeks in the second semester of 2006-2007. Participants met twice in a week and took four hours of lesson and each class session lasted 60 minutes for both groups. However, in the experiment group such sessions were followed by computer laboratory session with 60 minutes each.

The researcher thought to both groups of students and both groups took the lessons in the same order and same questions are solved in both classes. The lessons were prepared by the researcher and two other colleagues that are mentioned above commented on contents of lesson according to the objectives and text book from the official textbook of Ministry of National Education for 10<sup>th</sup>

grade textbook. The lessons include tabular, graphical and algebraic representation of quadratic equations, their translations, and their properties depending on coefficients and discriminate of the equations and the symmetry axis.

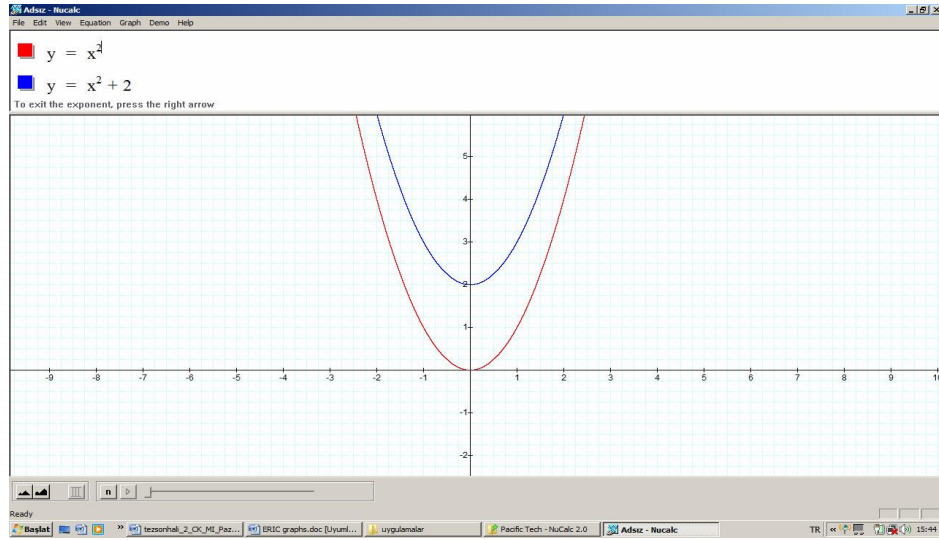
For the experiment group, lecture notes are given to the students in the lessons and the notes are reflected on the screen of IWB. However the control group students need to take notes in the lessons so sometimes the duration of lectures took longer as compared to the experiment group. The experiment group took computer laboratory sessions after lessons. The activities helped students to explore and interpret relationship between knowledge that they learn in the classroom, also it gave opportunity to draw multiple graphics in order to observe and interpret relationships between coefficients of equations.

The computer program used in the study is Nu-Calc. Nu-Calc (Pacific Tec, 2000) is graphing software to investigate symbols, functions and graphics. In order to draw a graphic, the user only needs to enter the equation and press the enter button. Then the graphic is drawn so there is no need to memorize any command syntax. The software supports parametric curves, implicit functions, density plots, contour plots, vector fields and inequalities. It also supports both standard Cartesian graphics as well as polar, rectangular and cylindrical and spherical graphics. The typical screen of the computer is given in figure 3.1.

It is possible to draw multiple graphics with different colors on the same screen so that users can compare graphics by their coefficients. Moreover zoom in and zoom out options are available in the program and the most powerful feature of the software is its capability to turn any equation into an animation by typing “n” in the equation. The software recognizes it as a parameter and equations can be animated on any variable, and on any defined domain.

The experiment group was thought about Nu-Calc before the treatment by the researcher and it took 60 minutes. And during this time students learned coordinate system, points on the coordinate systems, to draw first degree equations graphics,

to draw more than one graph in one coordinate system, to draw second degree equations graph, to draw more than one equation, to draw equation at any degree and other function graphics like sine, cosine, and absolute value.



**Figure 3.1** A screen shot from the software Nu-Calc.

The pre-test was applied to both groups of the students before the treatment in order to observe the prior knowledge about second degree equation graphics. After the treatment, the post-test was administered to both groups in order to assess their success in the subject. Both pre-test and post-test consist of same number of question with same index. After a delay of two months, same post-test were given to both groups in order to assess the retention of the concept. These three tests were given to examine students' strategies to find solutions, and to observe differences between students' solutions in both experiment and control group. Moreover, the attitude scale towards mathematics and technology (for both IWB and computer) were applied to the experiment group before and after the treatment in order to observe their attitude changes.

After the treatment and post test had been conducted, researcher made interviews with six students from the experiment group. The students were chosen according



to their success in pre-test and post-test. Three of the students got zero from their pre-test however after the treatment they got higher test scores, three of them got average test scores, and after the treatment they got higher test scores. The higher and average test scores were determined according to the mean score of the experiment group. The interview was conducted in order to obtain more information about the effects of the technology that was used. Open ended questions were asked in the interviews.

SPSS 16.0 was used to analyze the test scores of groups. After scoring each item for the GAT, ATTS and ATMS, the descriptive and inferential statistics were calculated for each test and the frequencies and percentages for each item on the test were computed.

### **3.3 Instruments**

The instruments used in the study were graphic achievement test (GAT), Attitudes towards Mathematics Scale (ATMS), Attitudes towards Technology Scale (ATTS). Furthermore interview was conducted so as to gain more and deeper information.

#### **3.3.1 Graphic Achievement Test (GAT)**

Graphic achievement test was one of the instruments that were used to investigate students' performance on graphing. The test consists of 15 questions and some of the questions have sub-questions. Ten of the questions were multiple choices, three were matching questions and the rest were essay type of questions. All of the questions, including the multiple choices need explanations, so even if the students mark the correct choice they need to explain their answers. So although question types seem to be different, students need to explain their answer to get full point. Each question and even the sub-questions assess different skills and different knowledge about quadratic equations graphing. The questions assess three categories mainly; translation (translation among algebraic, tabular and graphical representation, moving the given graph with desired units), classification (classifying the given graph using properties and coefficient) and drawing (drawing parabola from a given quadratic equation). The classification and

translation tasks need interpretation but the drawing task involves steps to follow. Some of the questions involve more than one task or students may answer the question using different tasks. Besides these three tasks, students also need to know scaling task for all questions; so scaling task involves in the entire questions in the GAT. The following table summarizes the content of GAT.

**Table 3.1** The content of GAT

Item No	Task	Number of Sub-questions	Item type
1	Translation task (Equation to graph) Classification task	4	Essay type
2	Translation task (Equation to graph) Classification task	-	Multiple choice
3	Translation task (Equation to graph) Classification task	-	Multiple choice
4	Classification task	-	Item matching
5	Translation task (Equation to graph) Classification task	-	Item Matching
6	Translation task (Equation to graph) Classification task	7	Item Matching
7	Translation task (Graph to equation)	-	Multiple choice
8	Translation task (Graph to equation)	-	Multiple choice
9	Translation task (Table to graph)	-	Multiple choice
10	Translation task (Graph to table)	-	Multiple choice
11	Translation task (Graph to equation)	-	Multiple choice
12	Translation task (Graph to equation)	-	Multiple choice
13	Classification task	4	Essay type
14	Classification task	-	Multiple choice
15	Classification task	-	Multiple choice

All of the questions specify the objectives of the Mathematics Curriculum of Turkish Ministry of National Education. All of the questions prepared by the researcher considering the MEB textbook and related literature and questions were controlled by three other mathematics teachers. They evaluated the questions according to their level of difficulty, accuracy of wording, suitability of the objectives. They suggested to add questions about finding the axes of symmetry directly from the formula in order to assess the knowledge about formulation. Moreover, they also suggested having two forms of test to use as pre-test and post-test since the students were old enough to remember the questions, especially the multiple choice questions. Therefore, by considering such comments, pre-test was designed different than the rest, whereas post-test and delayed post-test were the same. Pre-test consists of same number of questions with same context with the other two tests. The only difference between the pre-test and the others is that different numbers are given in every question assessing the same objective. 50 minutes are given to the students to complete the test.

In order to evaluate the students' responses; 0, 1 and 2 points were given to each question and sub-questions. If there was no or wrong response, it was evaluated as 0. If the correct choice or drawing without explanation were given it was evaluated as 1. And if there was correct answer with complete explanations, then it was evaluated as 2. The maximum grade was 58 and minimum was 0 in all of three tests.

The post-test was piloted to 75 students chosen from three different dersanes in Ankara. 60 minutes were given to complete the test; however students finished one test in 40 or 50 minutes. After the test, students were interviewed in order to observe if the questions are easy to understand, if there is any incorrect or incomplete question and also to assess the reliability and consistency. After the pilot study the test remained unchanged since the students had no difficulty to understand the questions and there weren't any incorrect question in the tests. The reliability of the test was examined and the corresponding alpha value was .82 which indicates that there is strong acceptable degree of internal consistency.

### **3.3.2 Attitudes towards Mathematics Scale (ATMS)**

There are 40 questions in the mathematics attitude scale in order to investigate students' attitude toward mathematics. All of the 40 questions are five point likert types with 28 positive and 12 negative statements. The five responses are strongly disagree (A), disagree (B), undecided (C), agree (D) and strongly agree (E). The students are expected to locate appropriate letter in each statement. Each statement are graded as 0,1,2,3 and 4; the strongly agree choice (E) is scored as 4 and strongly disagree (A) choice is scored as 0 for positive items where as the strongly agree choice scored as 0 and strongly disagree choice scored as 4 for the negative items. Possible scores for the ATMS ranged between 0 and 160. Scores near 160 indicate that students have positive attitude toward mathematics, 80 indicate that students neutral about the mathematics whereas scores near to 0 shows that students negative feeling for the mathematics. The test is completed in 20 minutes. The test was administered to the experiment group before and after the treatment to assess the students' attitudes and attitude changes toward the mathematics.

### **3.3.3 Attitudes toward Technology Scale (ATTS)**

This is the second attitude test used in the study to assess students' attitude toward technology use in the mathematics lessons. The test consists of 20 questions related with confidence in technology use, technology use in mathematics lessons and mathematics confidence. There are 19 positive statements and 1 negative statement in the test. There are five possible answers for each statements; never, occasionally, half of the time, usually, always. Students are expected to put a check near the box for each of the statement indicating the frequency of occurrence of the behavior and each statement scored as 0, 1, 2, 3 and 4. Never marked as 0 and always marked as 4 and the others 1, 2 and 3 respectively. Therefore the maximum score for the test is 80 and minimum is 0. The higher scores indicate positive attitude towards technology whereas lower scores indicate negative attitude towards technology. The test is completed in 10 minutes. The test was administered to the experiment group before and after the treatment to assess students' attitudes and attitudes changes toward technology.

The first ten items are about attitude towards computer technology, and the last ten items are about interactive whiteboard. The first ten questions are taken from the mathematics and technology attitudes scale (MTAS) prepared by Barkatsas, Pierce and Stacey (2007). Although the original scale consists of twenty items, ten items were omitted because they attempt to measure the mathematics attitude, mathematics confidence. In the study, the ATMS has similar items. The remaining ten items measure the attitudes towards computer technology. The statistical analyses for these items indicate that each sub-scale for the test has acceptable degree of internal consistency. The corresponding reliability analysis with desired Coranbach's alpha values for the sub-items are as follows; confidence in using technology is .79 and attitude to the use of computer technology to learn mathematics is .89. This indicates that there is a strong or acceptable degree of internal consistency in each subscale. The last ten items taken from the computer attitude questionnaire are developed by Christensen and Knezek (1996) for middle and high school students. The scale measures IWB enjoyment and motivation, IWB importance, IWB use to learn mathematics. And the corresponding reliability analyses for these subscales are .80, .84 and .81 respectively.

Since the items for ATMS and ATTS are translated to Turkish from English, the translated version was controlled by two English teachers. They check for the grammar, incorrect or misuse of words and understandability of the questions. After the translations, both of the tests were administered to 75 students as a pilot study chosen from three different dersane in Ankara. The students complete the ATMS in 20-25 minutes and ATTS in 10-15 minutes. When examining the reliability of the ATMS and ATTS pilot tests the corresponding alpha values are .75 and .81 respectively, indicating there is acceptable degree of internal consistency.

#### **3.3.4 Interview with Students**

In order to obtain deeper information about the study and the technology that is used in the study, semi-structured interviews were conducted with six students and videotaped. The students were chosen considering the mean sores of ATTS, ATMS and GAT before and after the treatment. Three students got zero from the

post test of GAT and lower attitude scores and got higher scores after the treatment and three of them got average mean GAT test score and average or above the average attitude scores and got higher after the treatment. None of the students got lower grade after the treatment.

Before the interviews the researcher talked with students and explained the content of the questions in order to make them feel comfortable and to give honest answers and also got permission to record the interviews. Before recording, students read the question and think about their answers; after that the researcher asked the question one by one to the students. The questions were open ended. The four beginning questions were about students' background about graph concept and their opinion about the concept before and after the treatments. The questions;

- Did you study the subject before the treatment or take lesson about it?
- What is your opinion about the concept of graphing before and after the treatment?
- How does the computer and IWB change your opinion about mathematics and technology use in mathematics?
- Would there be any difference if the subject was told with the blackboard?

The rest of the questions were about the IWB use, computer laboratory and their opinion and feelings about these two technologies and their contribution to their learning. Students explained their feeling for the activities, how these activities helped their learning, which activities they liked the most and the least, which activities they benefited most.

After conducting interviews, the video analysis was made. The video analysis was conducted such that the words that students used to describe their feelings about graphic concept, IWB and computer were coded. Then students that used the same words were counted.

### **3.4 Treatment Procedure**

The experiment and the control groups took the lessons in the same order. The concepts that are thought for each lesson are summarized in Table 3.2.

**Table 3.2** Objectives for each lesson

Time		Concept
Week one	Lesson one	<ul style="list-style-type: none"> <li>• Definition of second degree equation</li> <li>• Finding the roots of second degree equation: with factorization with general solution set by finding discriminant which is <math>\Delta=b^2-4ac</math></li> <li>• Interpreting the meaning of <math>\Delta</math> if it is equal to, bigger than or smaller than zero</li> </ul>
	Lesson two	<ul style="list-style-type: none"> <li>• Definition of parabola that is the second degree graph equation</li> <li>• Finding the intersection points of parabola</li> <li>• Finding the symmetry axes of parabola</li> <li>• Constructing the table for the graph of parabola</li> <li>• Drawing the graph in the form of <math>ax^2</math></li> <li>• Interpreting the how changes in the coefficient of a affect the parabola</li> <li>• Drawing the graph in the form of <math>ax^2+c</math></li> </ul> <p>Interpreting the how changes in the coefficient of c effect the parabola</p>

**Table 3.2 Continued**

	Lesson one	<ul style="list-style-type: none"> <li>• Drawing the graph in the form of <math>ax^2+bx+c</math></li> <li>• Interpreting the how changes in the coefficient of <math>b</math> effect the parabola</li> <li>• Interpreting and summarizing the how changes in the coefficient of <math>a</math>, <math>b</math> and <math>c</math> effect the parabola</li> <li>• Finding the equation of parabola if its intersection points of axes are given</li> <li>• Finding the equation of parabola if its symmetry axis given</li> <li>• Finding the equation of parabola if its tangent to the <math>x</math>-axes</li> </ul>
Week two	Lesson two	<ul style="list-style-type: none"> <li>• Connect the information about <math>\Delta</math> and the graph of parabola and coefficient.</li> <li>• If <math>\Delta &lt; 0</math> ,the graph do not cross the axes it stays above or below the <math>x</math> axes</li> <li>• If <math>\Delta = 0</math>, the graph tangent to the <math>x</math>-axes on the positive or negative side depend on the coefficients</li> <li>• If <math>\Delta &gt; 0</math>, the graph cut the <math>x</math>-axes with two intersection points</li> <li>• Interpret the coefficients of <math>ax^2+bx+c</math></li> <li>• If <math>a</math> is positive then the shape of parabola look is upward</li> <li>• If <math>a</math> is negative then the shape of parabola look downward</li> <li>• If <math>c</math> is positive, the graph cut the <math>y</math>-axes in the positive side the parabola goes up with <math>c</math> unit.</li> </ul>



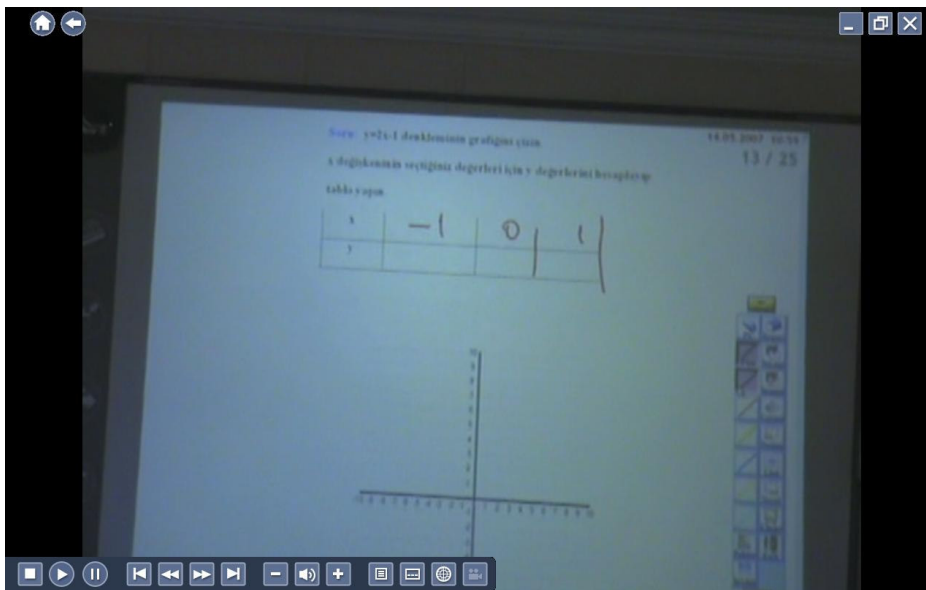
### 3.4.1 Treatment in the Experimental Group

The experiment group learned the graphing subject by using IWB and computer. The subject had been thought by the researcher herself. The students got 60 minutes lesson to learn the properties of the program Nu-Calc on their associated computer. Since the program is not complicated 60 minutes were enough to get used to the program. After this treatment, students learned to draw graphics, multiple graphics, and draw graphics with exponents and quadratic functions, graphics of trigonometric functions, derivatives and square roots. Also they learned how to animate the graphics. On the other side, students did not need to practice with IWB since the IWB was used only by the teacher.

The first part of the treatment took place in the classroom where the IWB was present. The lessons were given in the order that is shown in the table 3.2. Before the lessons, the notes were prepared by the teacher and were distributed to the students. The notes consisted of the definitions, main and subtitles and also examples. However the examples were not solved in order to be solved together in the classroom. The notes were reflected on the IWB screen, so that students had more time to listen and they did not need to write down the information and definitions and this time used for discussion and solving more examples. The graphics and tables were ready to draw and to fill in at IWB. Such graphics and tables were also present in the students' notes. So the teacher and the students together constructed the table values and drew the graphics on the coordinate system. After drawing a couple of graphics, multiple graphics with different colors were drawn on the same coordinate system. So, the students had a chance to compare and contrast the graphics and interpret their properties which are connected to the solution sets. Also they learned to translate the graphics. That is knowing only the graph of  $x^2$ , students could draw the graphics of  $x^2+a$ ,  $(x+a)^2$ ,  $ax^2+bx+c$  without any calculation. The following figures (figure 3.1) show the environment of the classroom.



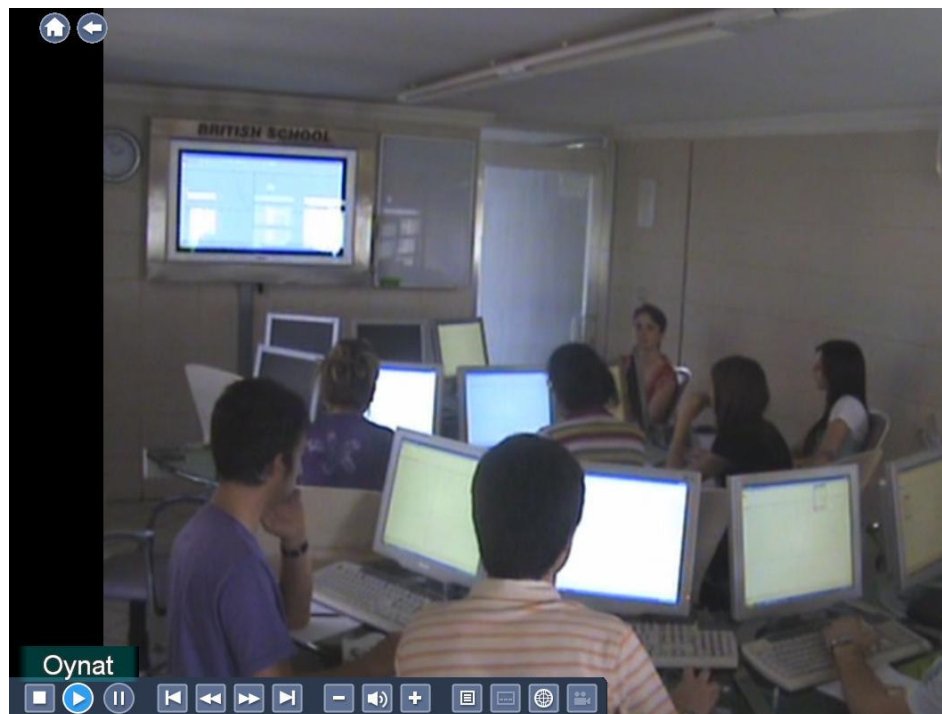
(a)



**Figure 3.2.a** Classroom environment with IWB in the experiment group

**b.** IWB screen in the experiment group

After the lessons with IWB, the computer laboratory took place. Each student had one computer to practice and the researcher had the main computer that was connected to the screen. All the computers were placed towards the screen so that students had a chance to check their answers from main computer screen that is reflected to the TV screen. With the activities in the laboratory, students continued doing algebraic, tabular, graphical representations and translation problems. However, this time the researcher showed only the first activity and the whole class discussed the results together; then the rest of the activities were done by the students on their own separately. Moreover, before drawing the graphics, students were expected to draw by hand firstly and then to check from the screen. With these activities, students were expected to practice the properties and use the computer as a checking tool. However, when they had a problem, they were free to ask to the researcher. In the laboratory session, students did not face any difficulty with the program. The figure 3.3 shows the laboratory environment.



**Figure 3.3** Laboratory environment for the experimental group.

The first lesson was given in the following order; definition of quadratic equations and their examples; then finding the roots of these equations by factorization and finding general solution set by calculating discriminant which is  $\Delta=b^2-4ac$ . After such activities, interpreting the meaning of discriminant comes; whether it is equal to, bigger than or smaller than zero. The lesson began with distributing the notes to the students and then the same notes were reflected on the IWB screen. The notes begin with the definition of quadratic equations. After definition, one example is given by the teacher and then students continued to give more examples. Then the subject continued with the finding solution sets (roots) of these equations. The first way to find roots is factorization. It consists of four parts depending on the coefficients of the equation. The examples are ready on the notes. However, the solution parts are left blank and the first example was solved by the teacher and the others by students. After finding the solution set by factorization, students learned discriminant to examine the roots if the equation cannot be factorized. The notes were followed by students again, the teachers made explanations about discriminant, and first example was solved by the teacher and then students solved the others, the examples and solutions sets changed with coefficients. So, until this part of the lesson, the IWB was used as a blackboard but only advantageous students spend less time on writing and solved more examples and spent more time to discuss the way to find roots of the equations and how discriminant changed with coefficients. After this lesson, students learned the fundamental part. And then the lecture continued with drawing of quadratic equations. Like the first lesson, students followed the notes; but the lesson included drawings with the program Nu-Calc. The first drawing is in the form of  $ax^2$ . First of all, the table already drawn in the notes and reflected on the board was constructed, so the students and the teacher together filled the table deciding the values of  $x$  and  $y$ . After constructing table, the students and teacher draw the graph together in the coordinate system given under the table. After this example, students draw  $y=2x^2$  in a separate coordinate system and after that draw  $y=3x^2$ . All the tables and coordinate systems were given for each example. After learning the steps, the nu-calc was used to draw the same graphics so that students checked their graphics

and observed the graphics by using zoom in and zoom out options. So they observed the graphics in more details with changing scale. After that students observe the changes by animation; the use of “n” that is mentioned before. With changing n values, the graphic is opened up or closed or look downward or upward. After that all the class and the teacher discussed how coefficient “a” changed parabola. After that, such procedure was done for  $ax^2+c$ ,  $ax^2+bx$ ,  $ax^2+bx+c$  and, the changes in parabola with coefficients were discussed. In the last lesson, the students and the teacher drew more graphics manually and with nu-calc and discussed discriminant, intersection points, symmetry axis, changes in coefficients, and translation together. For example, by looking the graph itself, students found intersection points, symmetry axis.

### **3.4.2 Treatment in the Control Group**

In the control group, students learned their lesson with traditional learning style. That is students took notes from the blackboard and solved the question that is asked. The teacher explained the concept by writing down the definitions and properties and wait students to write. This writing part took more time so the control group solved less problem compared to the experiment group. Nevertheless, they mainly solved the same problems with the same order. Like experiment group, the lesson begins with definition of quadratic equations and finding the roots of it. Students learn this by factorization and discriminant. After that the meaning of discriminant discussed. All the examples were the same as experiment group but since the students need to write down all the things from blackboard it takes more time compared to experiment group. After all, the drawings were thought. The first drawing is in the form of  $ax^2$ . First of all students construct a table, students and teacher together construct the table by deciding x and y values. After constructing the table, teacher draws the graph in the coordinate system. And then students were waited to draw the table and graph after that students were asked to draw  $y=2x^2$  in a separate coordinate system and after that draw  $y=3x^2$ . Then students discussed the how coefficient affects the parabola. Then the graph of  $ax^2+c$ ,  $ax^2+bx$ ,  $ax^2+bx+c$  drawn and discuss the

changes in parabola with coefficients. However fewer examples were drawn comparing to the experiment group since it takes more time to draw graph manually. More time spend on drawing and waiting for students to draw the graphics and less time spent on discussion.

Also the students compared the graphics in one coordinate system but since without having too many colors sometimes graphics are confused by students. They had difficulty to choose which graph belongs to which equation. Moreover they comment less on graphics and its properties. Therefore the teacher needs to give their properties directly.

Both groups took the lessons by the researcher. The definitions and same examples solved in the same order. However the control group solved a little less examples compared to the experiment group because of the writing and drawing took more time. The experiment group used the IWB and Nu-Calc as a tool for drawing graph. The more time spent on discussion for the experiment group, on the other hand the control group spent more time on finding values, constructing tables and drawing graphics.

### **3.5 Pilot study:**

In order to assess appropriateness of the lesson notes, activities, use of IWB and computers the pilot study was conducted. There were seven students in the pilot study and it covered all the topics mentioned before with the given order. The students were enthusiastic about the use of the IWB and computers in the lesson and their comments and interpretations lead a discussion environment in the class. Students talked more, gave more examples on their own and interpret the properties of quadratic equations and their graphics. They were mostly happy about not taking notes from the board and instead of writing down all the notes from the board they discussed the subject. Two of the questions were omitted from the notes because of mixed language and the difficulty of the questions. The students could not understand one of the questions and the other is too hard for the students if they did not know the four operations with square roots. Also some

changes were done during the pilot study as the order of the graphics to be drawn and the examples part that take place after the definitions. This part was left blank

in order to lead students to give example without any direction. Moreover, the space for some questions was not enough in the notes. However, there weren't any problems associated with the use of IWB and computers. But, students had difficulty with the translation among representations; tabular, algebraic and graphical. Therefore more questions were added about these concepts in the pre-test and post-test and also in the lessons. After the lessons with IWB and computer, interviews with students were conducted. Two students were interviewed and interviews took about 60 minutes; also all students wrote an essay about their feelings and lessons.

## CHAPTER 4

### RESULTS

In this chapter results of the pre-test, post-test, delayed post-test of GAT with attitude scale toward mathematics and technology are given. Beside these, qualitative analysis of the GAT items and interview results are presented.

#### 4.1 Descriptive statistics:

Graphic achievement test (GAT) administered as a pre-test, post-test and delayed-post test to both control and experiment groups. The descriptive statistics related to this data are given in table 4.1. Attitude scales for mathematics and technology (ATMS and ATTS) administered to the experiment group before and after the treatment and the descriptive statistic results are given in Table 4.1.

**Table 4.1** Descriptive statistics related to the scores from GAT as pre-test, post-test and delayed-post test, for experiment (N=32) and control group (N=33)

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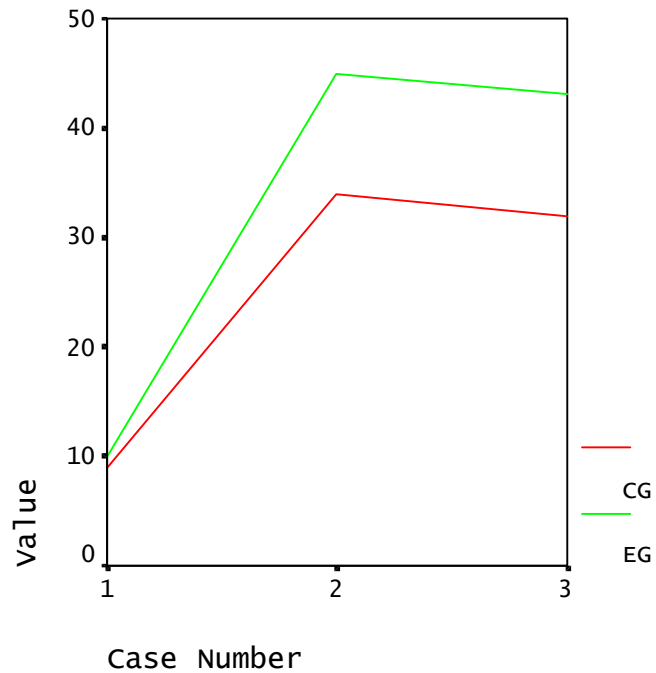
	Control group (n=33)			Experiment group (n=32)		
	Mean	Mode	SD	Mean	Mode	SD
Pre-test	9.78	0.00	8.63	10.78	0.00	9.15
Post-test	34.75	33.00	8.36	45.71	40.00	5.76
D. P. Test	32.30	28.00	7.26	43.25	42.00	9.15

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As it can be seen in Table 4.1, GAT mean scores of post-test are 4 times higher compared to pre-test. And in delayed-post test both control and experiment group's mean values show a slight decrease compared to post-test.



In addition to the numerical descriptive statistics, multiple line graph is also given for the pre-test, post-test and delayed post- test mean scores for control and experiment groups in figure 4.1.



**Figure 4.1** Multiple line graph showing the control and experiment groups mean scores from pre-test, post-test and delayed post-test

Considering the Figure 4.1, both experiment and control group got nearly the same mean score from the pre-test and both groups increase their achievement in post-test but the mean score for the experiment group increase more as compared to the control group. The two groups' mean scores for the delayed-post test decreased slightly whereas the experiment group still has higher mean score compared to control group.

**Table 4.2** Descriptive statistics related to the scores from ATMS and ATTS for experiment group (N=32)

	Mean	Mode	SD
PREATMS	33.37	34.00	7.90
POSTATMS	65.78	65.00	3.58
PREATTS	55.09	53.00	19.27
POSTATTS	103.18	100.00	11.40

Table 4.2 shows that, from PREATMS to POSTATMS, the experiment group showed a mean increase of 32.41 (from 33.37 to 65.78). Also the figure 4.2 shows that, there is a noticeable mean score increase in the PREATTS and POSTATTS from 55.09 to 103.18. This result indicates that students developed positive attitude toward technology and mathematics after the treatment.

In addition to the descriptive statistic for the ATTS, the frequencies and percentages of the responses on each item were calculated to show the distribution of students' responses in Table 4.3. Concerning the pre-test and post-test, after the treatments students' responses to the items increased about 3 and 4 points. For example, in the item 17, "I concentrate better in class when a whiteboard is used to deliver instruction." before the treatment, 59.4% of the students undecided about the statement. However, after the treatment, 50% of the students strongly agree and %43.8 of the students agrees with the statement. Moreover, considering the item 12, "interactive whiteboard and computer helps me to learn mathematics better", before the treatment, students were mostly undecided and after the treatment they agree to use whiteboard on the mathematics lessons (agree 46% strongly agree 34.4%)

**Table 4.3** Frequencies and percentages of ATTS item

ATTS		Frequencies and percentages of ATTS item									
ITEM	Pre0	Post0	Pre1	Post1	Pre2	Post2	Pre3	Post3	Pre4	Post4	
1	3	0	6	0	12	4	7	18	4	10	
	9,4	0	18,8	0	37,5	12,5	21,9	56,3	12,5	31,3	
2	6	0	8	0	14	4	4	16	0	12	
	18,8	0	25,0	0	43,8	12,5	12,5	50,0	0	37,5	
3	4	0	12	0	9	6	7	13	0	13	
	12,5	0	3,75	0	28,1	18,8	21,9	40,6	0	40,6	
4	8	0	8	0	11	3	4	17	1	12	
	25,0	0	25,0	0	34,4	9,4	12,5	53,1	3,1	37,5	
5	2	0	8	0	14	5	4	11	4	16	
	6,3	0	25,0	0	43,8	15,6	12,5	34,4	12,5	50,0	
6	0	0	3	0	18	5	6	16	5	14	
	0	0	9,4	0	56,3	15,6	18,8	50,0	15,6	43,8	
7	8	0	14	0	6	6	4	16	0	10	
	25,0	0	43,8	0	18,8	18,8	12,5	50,0		31,3	
8	4	0	6	0	16	2	6	14	0	16	
	12,5	0	18,8	0	50,0	6,3	18,8	43,8		50,0	
9	3	0	10	0	12	2	6	15	1	15	
	9,4	0	31,3	0	37,5	6,3	18,8	46,9	3,1	46,9	
10	12	0	10	0	4	4	4	15	2	13	
	37,5	0	31,3	0	12,5	12,5	12,5	46,9	6,3	40,6	
11	7	0	6	0	15	6	1	16	3	10	
	21,9	0	18,8	0	46,9	18,8	3,1	50,0	9,4	31,3	
12	2	0	11	0	15	8	3	13	1	11	
	6,3	0	34,4	0	46,9	25,0	9,4	40,6	3,1	34,4	
13	8	0	12	0	5	5	7	12	0	15	
	25,0	0	37,5	0	15,6	15,6	21,9	37,5	0	46,9	
14	7	0	12	2	9	2	2	17	2	11	
	21,9	0	37,5	6,3	28,1	6,3	6,3	53,1	6,3	34,4	
15	6	0	9	0	11	5	6	15	0	12	
	18,8	0	28,1	0	34,4	15,6	18,8	46,9	0	37,5	
16	0	0	5	0	14	1	9	14	4	17	
	15,6	0	43,8	0	43,8	3,1	28,1	43,8	12,5	53,1	
17	4	0	9	0	19	2	0	14	0	16	
	12,5	0	28,1	0	59,4	6,3	0	43,8	0	50,0	
18	0	0	16	0	16	6	0	12	0	14	
	0	0	50,0	0	50,0	18,8	0	37,5	0	12,5	
19	1	0	8	0	18	1	5	15	0	16	
	3,1	0	25,0	0	56,3	3,1	15,6	46,9	0	50,0	
20	1	0	9	0	19	1	3	17	0	14	
	3,1	0	28,1	0	59,4	3,1	9,4	53,1	0	12,5	

On the other hand concerning the pre and post ATMS frequencies and percentages, students' positive attitude and feeling could be concluded. To illustrate, considering the item 21 "I feel comfortable in mathematics lessons", none of the students mark strongly agree, 6,3% mark agree, 31,3% undecided, 37,5% disagree and %25 strongly disagree showing that most of the students feel both uncomfortable in their mathematics lessons. On the other hand, after the treatment strongly agree increased up to 37,5%, agree increased up to %50 and undecided 12,5% showing that students are more comfortable mathematics lesson when IWB and computer technologies used.

#### 4.2 Inferential Statistics

This part covers the analysis of data that was collected during the study. ANCOVA was run in order to examine whether there was any significant difference between experimental and control group with respect to POSTGAT score after controlling PREGAT scores. The pre-test scores were assigned as covariate. In order to run ANCOVA the assumptions of ANCOVA was met. The first assumption is the homogeneity of regression slope. The interaction term including treatment and PREGAT was tested and the related significance is .779 (df=1, F= .079, Eta Square=.001) and this shows that the assumption is not violated. Another assumption of ANCOVA is to test of the homogeneity of variances with Levene's test. The result of the Levene's test is given in the Table 4.4.

**Table 4.4** Levene's test for equality of variances for POSTGAT scores.

F	df1	df2	Sig.
2.77	1	63	.101

As it appears in the Table 4.4, F values were found non-significant. This indicates that variances are equal across control and experimental group. The result of the ANCOVA was given in Table 4.5.

**Table 4.5** Result of the ANCOVA for POSTGAT

Source	Df	Mean Square	F	p.	Eta Squared
GAT	1	390.957	8.349	.005	.120
Treatment	1	855.013	18.259	.00	.230
Error	61	46.872			

As Table 4.5 displays, the effect of treatment had significant effect on POSTGAT [  $p = .000$ ]. This result showed that performance on POSTGAT was significantly influenced by the treatment after controlling PREGAT scores. Since there is a significant difference between two groups, in order to observe which group had higher mean score estimated marginal means were calculated and found that control group had a mean of 34.90 where as experimental group had a mean of 45.56. And this results show that the experimental group is more successful after the treatment after controlling PREGAT scores.

In order to test the hypothesis that there are any significant differences between control group and experimental group students with respect to their delayed post graphic achievement scores the ANOVA was run. Table 4.6 shows the result of the Levene's test and Table 4.7 shows the result of the ANOVA for delayed post GAT.

**Table 4.6** Result of the Levene's test for DPGAT

F	df1	df2	Sig.
3.155	1	63	.081

**Table 4.7** Result of the ANOVA for DPGAT

Source	Df	Mean Square	F	p.
DPGAT	1	7459.592	109.58	.000

As seen from Table 4.6, F values were found non-significant. This indicates that variances are equal across control and experimental group. Also Table 4.7 shows that there was a significant mean difference between experimental and control group with respect to their DPGAT.

Besides these analyses, the attitudes are analyzed using related sample t-test. The related sample t-test was run in order to examine whether there was a significant mean difference between PREATTTS and POSTATTTS scores in experimental group. The result of this analysis for the ATTS is that there was a significant difference in the ATTS scores ( $M= 21.31$ ,  $SD= 4.96$ ) for the experimental group,  $t(31)=24.303$ ,  $p= .00$ . This result showed that the experimental group POSTATTTS scores were significantly higher than the PREATTTS.

Moreover the same analyses was run for the ATMS; the related sample t-test used to examine whether there was a significant mean difference between PREATMS and POSTATMS scores in experimental group. The result of this analysis for the ATMS shows that there was a significant difference in the ATMS scores ( $M=48.09$ ,  $SD=10.20$ ) for the experimental group,  $t(31)=26,65$ ,  $p= .00$ . This

result showed that the experimental group POSTATTS scores were significantly higher than the PREATTS. Considering both results of the attitudes scores after the treatment students show more positive feeling and attitudes toward the mathematics and technology.

### **4.3 Qualitative Data Analyses**

The qualitative data obtained by the observation of the GAT and interview with students. As mentioned before, GAT applied as pre-test, post-test and delayed post-test. The Gat items observed in details because although both group students found correct solutions their solution strategies differs among groups and six students were chosen for interview about the graphic concept, computer and IWB. The six students were represented by the letters; A, B, C, D, E and F. The first three (A, B, C) got zero from the post test and got higher scores after the treatment and other three (D, E, F) got average test score and got higher after the treatment.

#### **4.3.1 Qualitative and Quantitative Results of the GAT**

All students' answers were examined according to the rubric. It contains all the possible answers and how much point to be given for each step. The full credit is given for the correct answers with explanations. The tests were evaluated by another mathematics teacher and some of the students' answers were evaluated differently by her. However after discussing the answers same credits were given or arithmetic mean was taken for such questions. Students' solution strategies differ for each question and each question assesses different knowledge and skills and so each question and their sub-questions were examined one by one.

#### **First Item:**

First item has four sub-question that asses different form of quadratic equations. The first one is in the form of  $ax^2$  that intended to observe students knowledge and skills about the basic quadratic equation. Students are expected to draw the graphics using the steps that were thought in the lessons. They construct a table giving at least three values of x and y (three values is necessary to draw quadratic equations). Then using the table, the graphics is drawn. Another solution strategy

is that; explaining that the graphics' cross over is at the origin, it is symmetric to y-axis and since the coefficient is positive, it looks upward. The students' answers frequencies and percentages given in the Table 4.8.

**Table 4.8** Frequencies and percentages f (%) for the first sub-question in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	11(33.3)	10(30.3)	12(36.4)	12(37.5)	8(25.0)	12(37.5)
POSTGAT	0(0)	10(30.3)	23(69.7)	0(0)	6(18.8)	26(81.2)
DPGAT	0(0)	13(39.4)	20 (60.6)	1(3.1)	8 (25.0)	23 (71.

Considering the table both group of students had difficulty with drawing before the treatment, but both groups of students' achievement increased after the treatments and they keep their success after a two month delay, also. Before the treatment, both groups of students drew line graphics, two different graphics (could be line, curve) or two or three dots in a coordinate system. And the students, who drew the graphics, used the steps as far as they remembered. However, after the treatment, the statistical analysis shows increase in both groups, but the explanations and solution strategies for the question are quite different considering both groups. The control group attempts to solve the problem step by step; constructing the table, finding values for x and y pairs, drawing them in coordinate system and drawing the graph. 27 of the control group students drew the graphics using the steps and the remaining 6 drew a graphics that passes from the origin without any explanation. On the other hand, 7 students drew the graphics that passes from the origin in experiment group like the other group. However the rest of the students drew the graph with different strategies; 19 of



them translate the graph of  $x^2$ , first they draw the  $x^2$  and then explain that the since the leading coefficient is positive the shape of the graph looks upward, and with the increase of the coefficient the graph get close to the y-axis. And the remaining explanations are that the graph passes through the origin and its symmetry axis is y-axis, so drawing one half and taking its symmetry.

The second sub-question attempts to measure quadratic equation graph skills in the form of  $y=ax^2+c$ . By adding “c” the graph will move on the y-axis depending on the “c”. Therefore besides knowing “a”, students also need to know the affect of “c”. The related frequencies and percentages for the question are given in Table 4.9.

**Table 4.9** Frequencies and percentages for the second sub-question in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	16(48.5)	2(6.1)	15(45.5)	11(34.4)	4(12.5)	17(53.1)
POSTGAT	1(3.1)	0(0)	32(97.0)	0(0)	1(3.1)	31(96.9)
DPGAT	0(0)	4(12.1)	29 (87.9)	0(0)	3 (9.4)	29 (90.6)

Concerning this item, frequencies and percentages, like first item both group of students’ grade increased after the treatment. However before the treatment percentages of drawing the correct graph are higher comparing to the first item. Although this item required more knowledge about the effects of coefficient, students found x and y intercepts and since these three points are required, students drew the graph. In the pre-test, all students that draw the graph correctly gave zero value to x and y to find the intercepting points and since the graph is correct they

got full mark. However, after the treatment, almost all of the students answered correctly. Considering their solution strategies, 25 of the students in the experiment group translated the  $x^2$  graph 4 units down on the y-axis and explaining that the coefficient of  $x^2$  shows that the parabola looks upward, and considering the constant -4, “we can say that the graph goes down 4 unit on the y-axis, the plus showing that the graph goes up and minus goes down on the y-axis”. Also they found the intercepting points on the x-axis. The rest of the students drew the graph by finding some x and y values and constructing table. On the other hand, 20 of the control group students followed the steps; finding values, constructing table, finding pairs on the coordinate system, then drawing the graph, most of the students found intercepting points and three of three students gave 1, 0 and -1 to x values and drew the graph.

The third sub-question is intended to measure the quadratic equation in the form of  $ax^2+bx+c$ . The third sub-question adds “bx” in equation and the symmetry axis and the graph changes. The related percentages and frequencies for both groups are given in the Table 4.10.

**Table 4.10** Frequencies and percentages for the third sub-question in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	22(66.7)	8(24.2)	3(9.1)	15(34.4)	8(25.0)	9(28.1)
POSTGAT	1(3.0)	3(9.1)	29 (87.9)	1(3.1)	1(3.1)	30(93.8)
DPGAT	1(3.0)	7(21.2)	25 (75.8)	1(3.1)	5 (15.5)	26 (80.6)

Like other questions, students increased their grade after the treatment. And the experiment group increased their grade a little more comparing to the experiment group. The explanations for this question vary among students. In the experiment group, 3 of the students tried to factorize the given equation, but cannot, and found the discriminant to show that since its bigger than zero the graph intersect x-axis at two points and gave zero for x and found intersection points on y, then drew the graph. These are the three papers that researcher and her colleagues had difficulty to evaluate since students guessed the shape and explained reasons but did not find the exact points on the axis and the shape that drawn is nearly the same. Also five of the students found x (by factorization) and y-intercept (giving x to zero) then drew the graph. However, seven of the students answered the question with more detailed explanations. Besides finding the intercept points, they calculated the symmetry axis and found its peak point. Also, they explained that the graph is symmetric to the peak point, the leading coefficient is positive so it looks upward; since it crosses the x-axis it has two roots. And the remaining students found the intersection points, drew tables, found these points on the coordinate system and drew the graph. On the other hand, almost all of the control group students follow the same steps. But they did not write any explanations. They found points and draw graph.

Fourth sub-question is again in the form of  $ax^2+bx+c$ . Since the leading coefficient is negative, the parabola looks downward. And it is easier to factorize the given quadratic equation. However the students' responses for this item are interesting considering the third item. Although this item is easier to draw, experiment group students are 11% less successful in drawing, on the other hand control group was 6% more successful. 25 of the control group students found intersection points and drew the graph. They gave zero value to x and y, and found the intersection points. And the rest of the students give 0, 1 and 2 to x and drew half of the graph and then they drew such half and explained that the graph is symmetric. However they did not find the symmetry axis and so did not find values for the other half of the graph. On the other hand, the experiment group students explained that graph looks downward and found only one intersection point then drew a graph and therefore could not get full mark. Also 22 of them

followed the same steps as control group. Related frequencies and percentages are given in Table 4.11.

**Table 4.11** Frequencies and percentages for the fourth sub-question in the PREGAT, POSTGAT and DPGAT

Score	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	29(87.9)	3(9.1)	1(3.0)	18(56.2)	6(18.8)	8(25.0)
POSTGAT	1(3.0)	1(3.0)	31 (93.9)	2(6.2)	3(9.4)	27(84.4)
DPGAT	0(0)	4(12.1)	29 (87.9)	4(12.5)	0 (0)	28 (87.5)

Considering the first item, it consists of four sub-items that each of them measure different skills and knowledge. Both groups of students increased their achievement after the treatment and high percentage of students correctly drew the graph and even after a two month delay. Although their achievement increased, their solution strategies differ for each question. The control group mostly follows the steps or gives values to x and construct table then draw graph. On the other hand the experiment group mostly gives explanations. Their explanations are like their conclusions in the lesson and computer laboratory. They try to explain what they see on the IWB and computer screen.

Considering the first item, students are expected to draw graphics from the given functions. Two of the students' answers for the first question are given in the following figure. The figure 4.2 shows the pre-test responses for students; the first paper belonged to control group student and the second paper belonged to experiment group student. And figure 4.3 shows the same students responses for the post-test.

In the pre-test both of the students drew the first two graphics correctly by giving values for x and calculating corresponding y values. And control group student put a question mark for the other two sub-questions. On the other hand, the experimental group student tried to draw some graphics but the answer for “d” does not even look like a graphic of parabola. On the other hand, after the treatment the control group student drew the first three graphics correctly. However she could not draw the last one, she calculate x and y pairs however could not draw the correct graphics. On the other hand experiment group students could not draw the correct graph for third sub-item. However she drew the others with explaining her drawings.

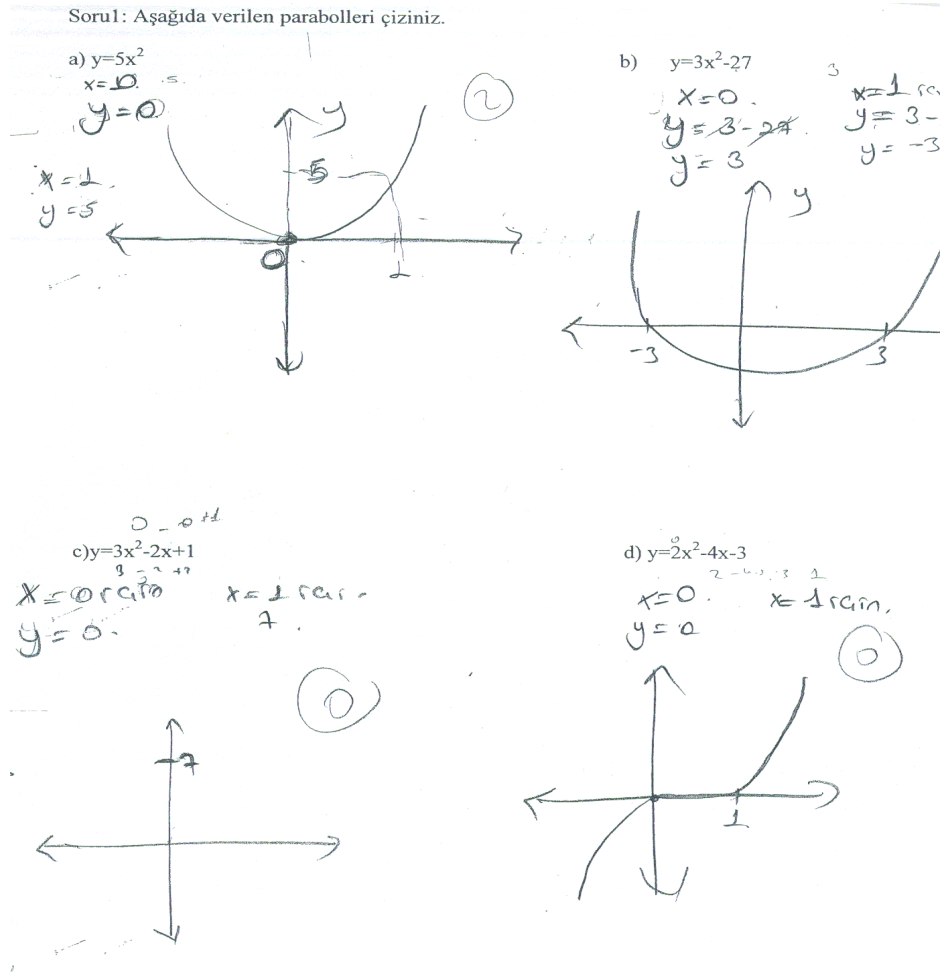


Figure 4.2. Students’ responses for the item one in pre-test.

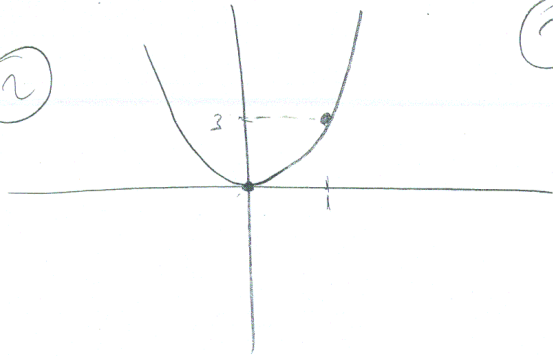
Soru1: Aşağıda verilen parabolleri çiziniz.

a)  $y=3x^2$

$x=0 \Rightarrow y=0$

$x=1 \Rightarrow y=3$

(2)

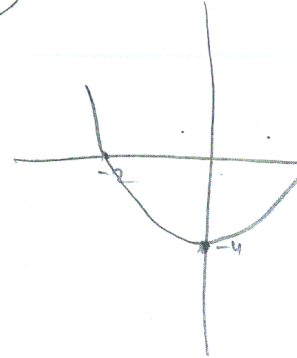


b)  $y=x^2-4$

$x=0 \Rightarrow y=-4$

$y=0 \Rightarrow x=2$

(2)



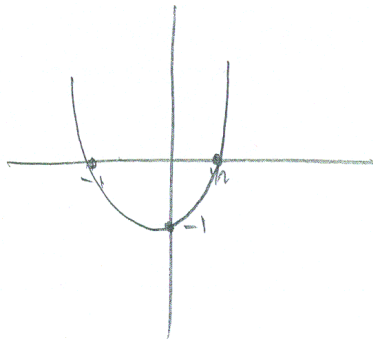
$2x^2 - x - 1$   
c)  $y=2x^2+x-1$

$x=0 \Rightarrow y=-1$

$y=0 \Rightarrow x=\frac{1}{2}$

$x=-1$

(2)



$-x^2 + 2x + 3$   
d)  $y=-x^2+2x+3$

$x=0 \Rightarrow y=3$

$y=0 \Rightarrow x=3$

$x=-1$

(0)

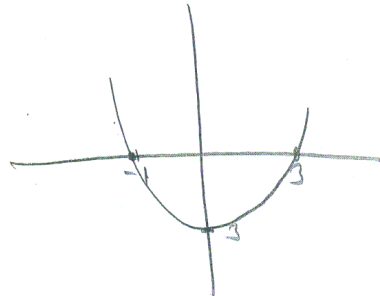
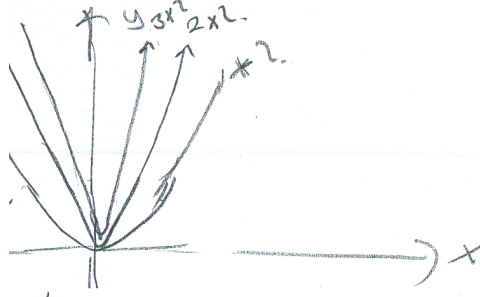


Figure 4.2 Continued

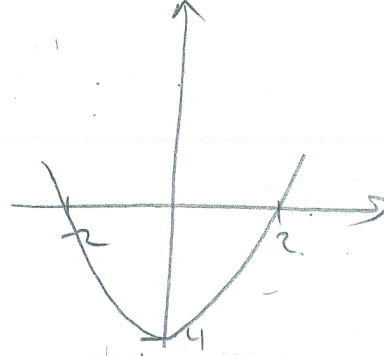
Soru1: Aşağıda verilen parabolleri çiziniz.

a)  $y=3x^2$



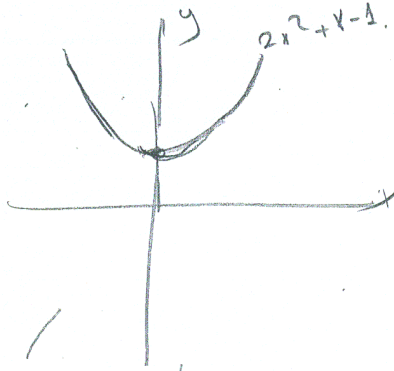
X'in katıyısı arttıkça,  
y' ekserine yaklaşıyor.

b)  $y=x^2-4$

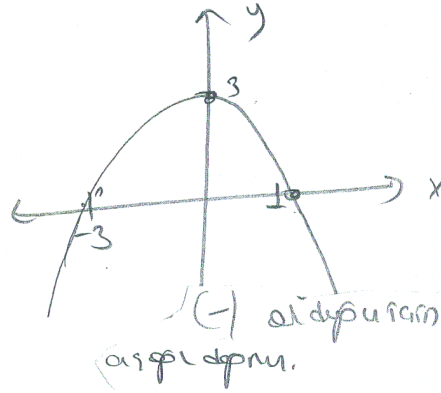


Julanda ve aşşpide  
aynımay'ı veriyen  
(-) aşşpü (+) yukarı  
 $x=0$   $y=-4$

c)  $y=2x^2+x-1$



d)  $y=-x^2+2x+3$



(-) aşşpü için  
aşşpü dırnu.

Figure 4.3 Students' responses for the item one on the post-test.

**Second Item:**

Second item looks similar to the first item except that it is multiple choices. Again the equations are given and the graphics are asked. Although it is multiple choices, students need to make explanations to get full mark. But it measures the quadratic equation in the form of  $ax^2+bx$  that is not involved in the first question. The related frequencies and percentages for the question is given in table 4.12.

**Table 4.12** Frequencies and percentages for the second item in the PREGAT, POSTGAT and DPGAT

---

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	14(42.4)	4(12.1)	15(45.5)	10(31.2)	6(18.8)	16(50.0)
POSTGAT	2(6.1)	11(33.3)	20(60.6)	1(3.1)	12(37.5)	19(59.4)
DPGAT	1(3.0)	15(45.5)	17 (51.5)	2(6.2)	12(37.5)	18(56.2)

---

Since this is a multiple choice question, students' PREGAT score is higher compared to the first question. Almost half of them found the correct choice in both groups. But it is seen that by examining their papers, they mostly found the correct choice by chance. That is in both group students eliminate the c, d and e choices, but then they mark a or b. The reason that they eliminate that the last one is that it is the only one that looks down, then they put zero for x and find zero so the c and d can be eliminated then they chose either a or b. Also, some of the students explained that since the coefficient of x is 1, the graph passes through one unit in x-axis. However after the treatment students explanations changed. 11 of the control group students drew the graph following the steps (finding values for x and y, making table, then drawing graph) and then choosing the correct choice. However 9 of them found intersection points by factorization then choosing the



answer. On the other hand, none of the experiment group students drew the graph by using such steps. First of all almost all of them wrote that the graphics look upwards, so the choice e cannot be the answer. 15 of them wrote explanations near each of the choice about why they cannot be the correct choice. They eliminated other choices by intersection points. The rest of them got one because they found the correct choice without explanation.

**Third Item:**

The third item is in the form of  $ax^2+bx+c$  but this is different from the other questions since it can be factorized as  $(ax+b)^2$ . Therefore the graph is adjacent to the x-axis. Related frequencies and percentages are given in Table 4.13

**Table 4.13** Frequencies and percentages for the third item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	16(48.5)	0(0)	17(51.5)	11(34.4)	6(18.8)	15(46.9)
POSTGAT	3(9.1)	6(18.2)	24(72.7)	3(9.4)	7(21.9)	22(68.8)
DPGAT	2(6.1)	11(33.3)	20 (60.6)	0(0)	11(37.5)	21(65.6)

Like other items, students showed increases in their scores after the treatment. Considering their solution strategies, 20 of the control group found the intersection points and drew the graph then chose the corresponding graph among the given choices. The rest of them gave values for x (generally 0 and 1 are preferred) and found corresponding y-values then mark them on each of the choices to find the matching graph. On the hand, 5 of the experiment group, who got 1 point on the test, found the correct choice but they wrote “I give values” and could not get full

point. Moreover, rest of them found the correct choices with variety of explanations and none of them drew the graph. Also, almost all of them eliminate “a” and “e” choices and explained that since the leading coefficient is negative it must look downwards. Also, since the leading coefficient is negative it is difficult to factorize for the students, ten of them found the discriminant as zero and concluded that the graph must be adjacent to the x axis therefore the “c” and “d” choices are eliminated and therefore the b is the correct one. And five of them took the equation to minus parenthesis then factorized the equation and since it’s a square they explained that the graph looks downward and adjacent to the x axis. Finally, the rest of them used the choices to explain why each of them is eliminated.

Two of the students’ responses for the item three are given in the figure 4.4. The first one belonged to control group student and the second belonged to experiment group student. The control group students drew the desired graphics by given values for x and find corresponding x and pairs and choose the corresponding graphics. However, the experiment group student, use the being adjacent to the x-axis and even drew the “a” and “b” choices corresponding graphics. Both students got full mark for this item.

#### **Fourth Item:**

The fourth item is intended to learn students’ knowledge for the leading coefficient. From the previous items it shows students have knowledge only for signs; minus shows downward graph and plus show upward graph. But with this item, students need to distinguish the difference if the coefficient gets larger or smaller.

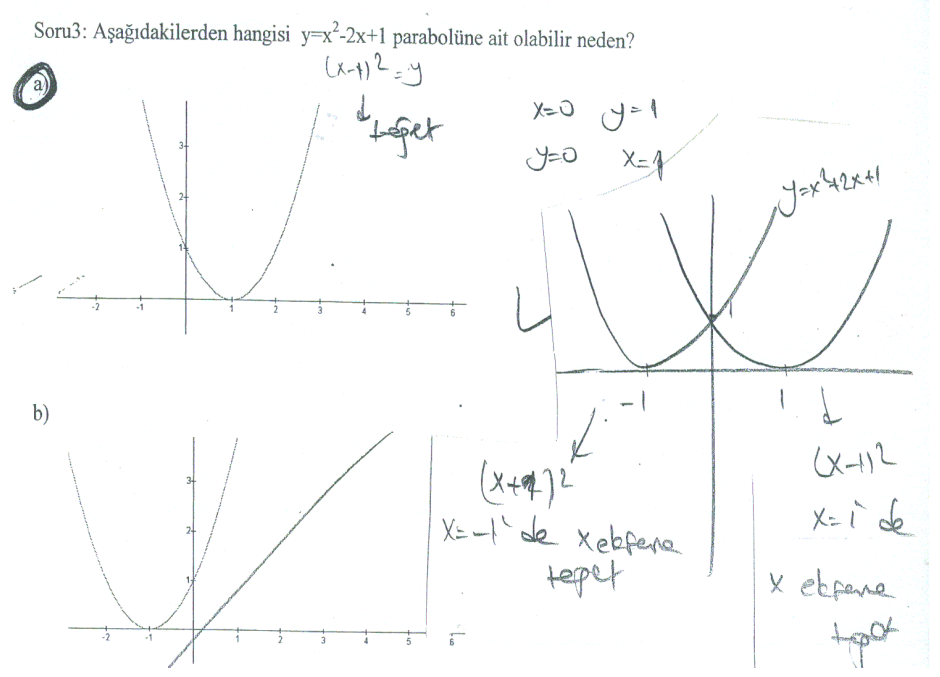
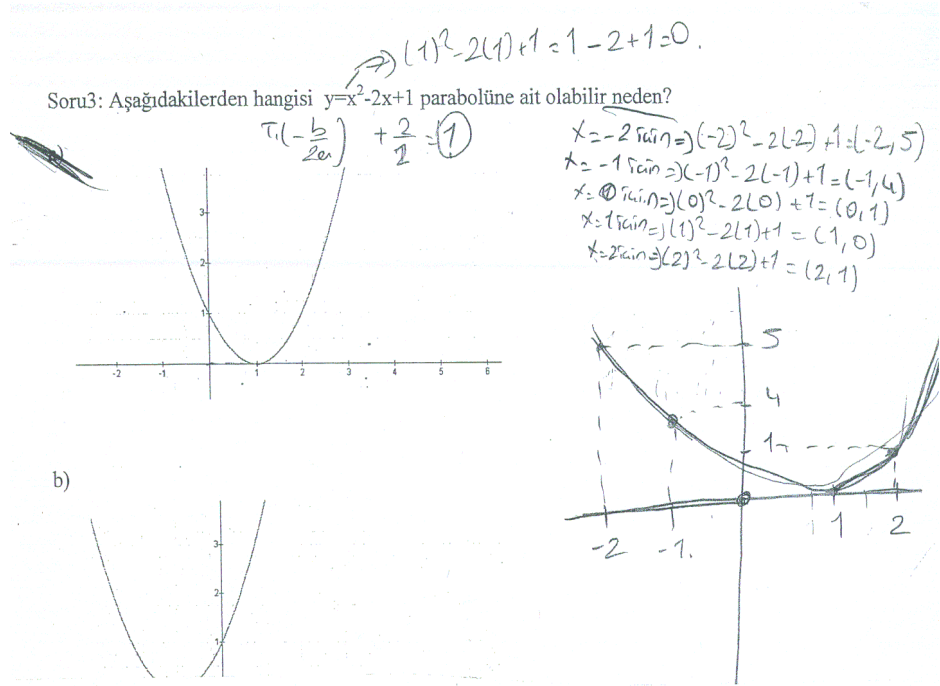


Figure 4.4 Students' responses for item three in the post-test.

**Table 4.14** Frequencies and percentages for the fourth item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	16(48.5)	17(51.5)	0(0)	3(9.4)	7(21.9)	6(18.8)
POSTGAT	3(9.1)	6(18.2)	24(72.7)	3(9.4)	7(21.9)	22(68.8)
DPGAT	2(6.1)	11(33.3)	20 (60.6)	0(0)	11(34.4)	21(65.6)

Both groups of students gave the correct answer for the question. But control group's grades were increased more and after a two month delay decreased more compared to experiment group. Their explanations are less satisfied comparing to the experiment group in the post test, also. However, the experiment group shows almost the same success in the post-test and delayed post-test. Students in both groups mostly explained that the graph is upward if the leading coefficient is positive, then the graph looks upward and the graph gets closer to the y-axis, if the leading coefficient is getting larger and the graph looks downward if the leading coefficient is negative. This item shows that although control group students know the effect of leading coefficient, they did not use this knowledge on the other items; they just explain when the question is directly related to this knowledge.

**Fifth Item:**

The fifth item is a matching type and intended to learn students' knowledge on quadratic equations by asking them to find the correct choices using discriminant. One of the equation's discriminant is smaller than zero therefore it does not have reel roots and it does not cross the x axis, the other equation has discriminant equal to zero so it has one root adjacent on the x axis, and third one has discriminant larger than zero so it crosses the x axis at two points. Related frequencies and percentages given in the Table 4.15.

**Table 4.15** Frequencies and percentages for the fourth item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	24(72.7)	6(18.2)	3(9.1)	21(65.6)	4(12.5)	7(21.9)
POSTGAT	2(6.1)	12(36.4)	19(57.6)	1(3.1)	11(34.4)	20(62.5)
DPGAT	6(18.2)	10(30.3)	17(51.5)	0(0)	11(34.4)	21(65.6)

Like other items, both groups of students showed better results after the treatment. However, control group students had difficulty to find the correct graph since it is seen that most of them erased and drew many graphics on the papers. Since one of the discriminant is less than zero, they sometimes found roots by mistake and were not able to match the graph. Seven of them gave values for  $x$  and find corresponding  $y$  values and tried to match them with the given graphics. Also five of the experiment group students solved the question with the same strategy. Moreover, in the experiment group seven of the students solved the question by using symmetry axis. They found symmetry axis using the formula  $-b/2a$  and found the correct choice. This is the first time that students used finding the symmetry axis as a method. And the remaining experiment group students used discriminant. Three of them explained that by looking at the shapes of the given graph, calculating the discriminant is enough for solution. The graphics has two, one or no point on the  $x$ -axis according to the value of the discriminant, by such knowledge such students matched the given parabolas. Although students mostly answered the question, the control group had difficulty to match the graphics, because they could not easily found the roots of the given equations. Also, they had difficulty to draw and none of them thought to use discriminant or symmetry axis.

Two students' responses for the item four and five are given in the Figure 4.5. The first paper is from control group student and the other is from the experiment group student.

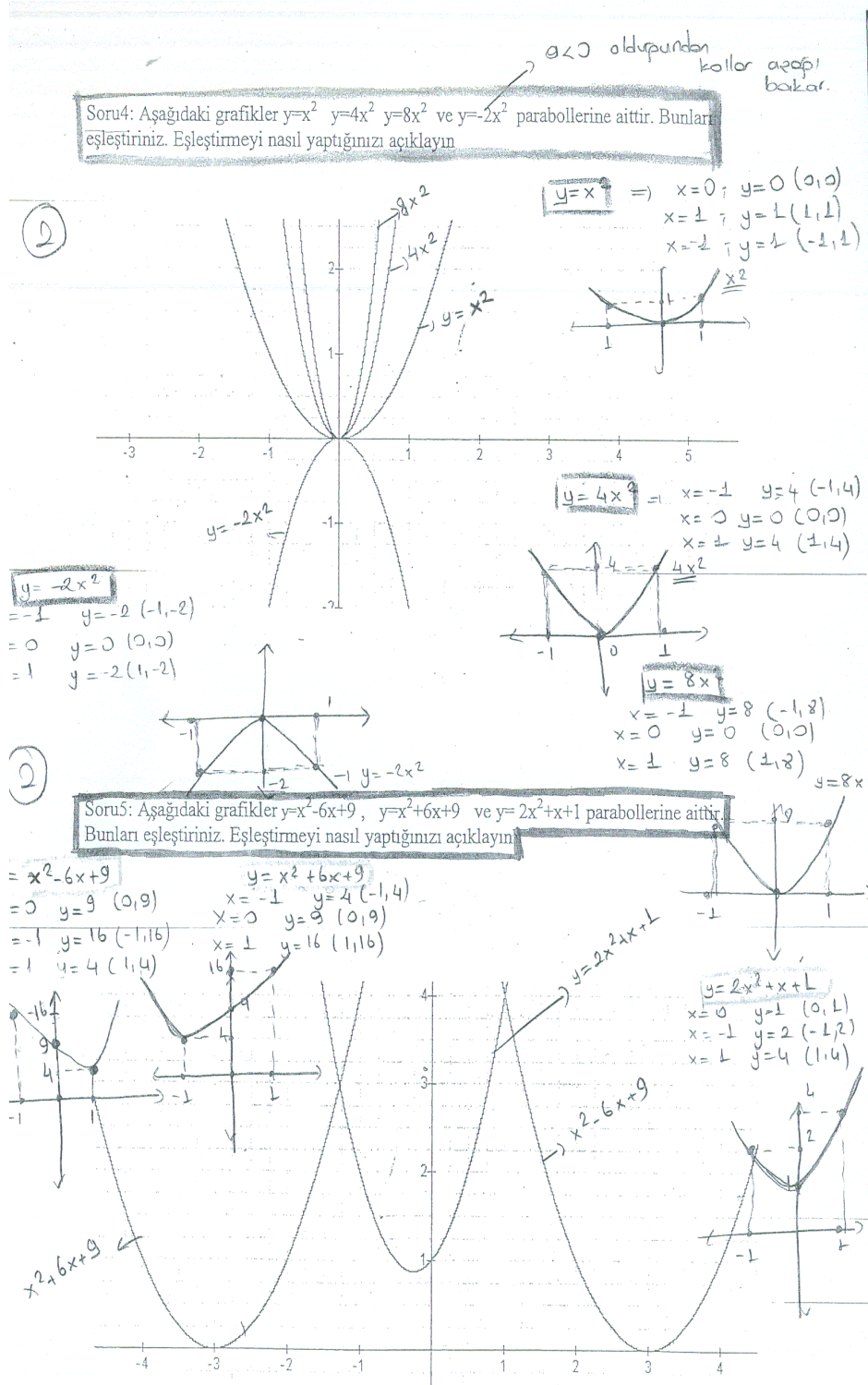
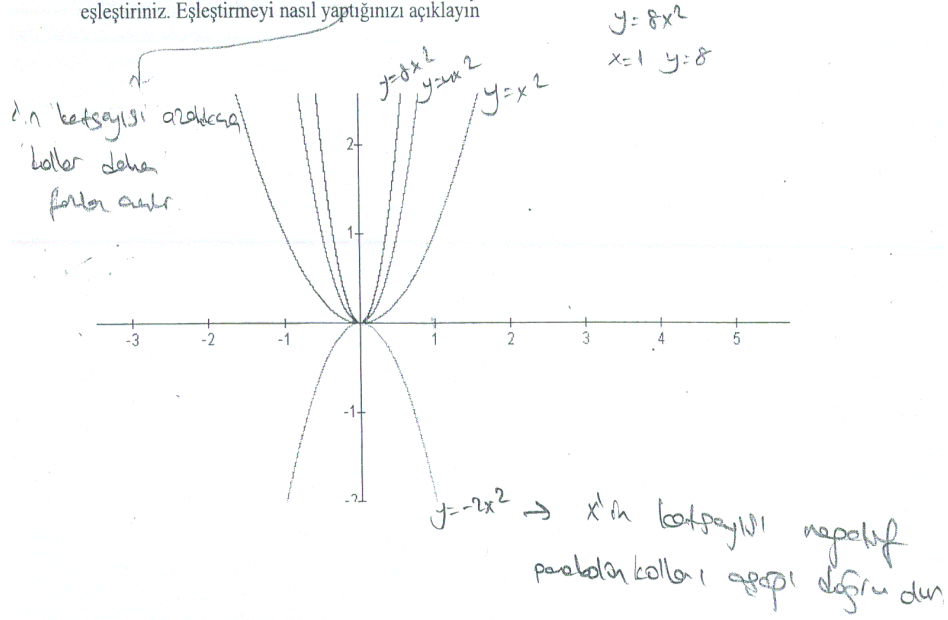


Figure 4.5 Students' responses for item fourth and fifth.

Soru4: Aşağıdaki grafikler  $y=x^2$   $y=4x^2$   $y=8x^2$  ve  $y=2x^2$  parabollerine aittir. Bunları eşleştiriniz. Eşleştirmeyi nasıl yaptığınızı açıklayın



Soru5: Aşağıdaki grafikler  $y=x^2-6x+9$ ,  $y=x^2+6x+9$  ve  $y=2x^2+x+1$  parabollerine aittir. Bunları eşleştiriniz. Eşleştirmeyi nasıl yaptığınızı açıklayın

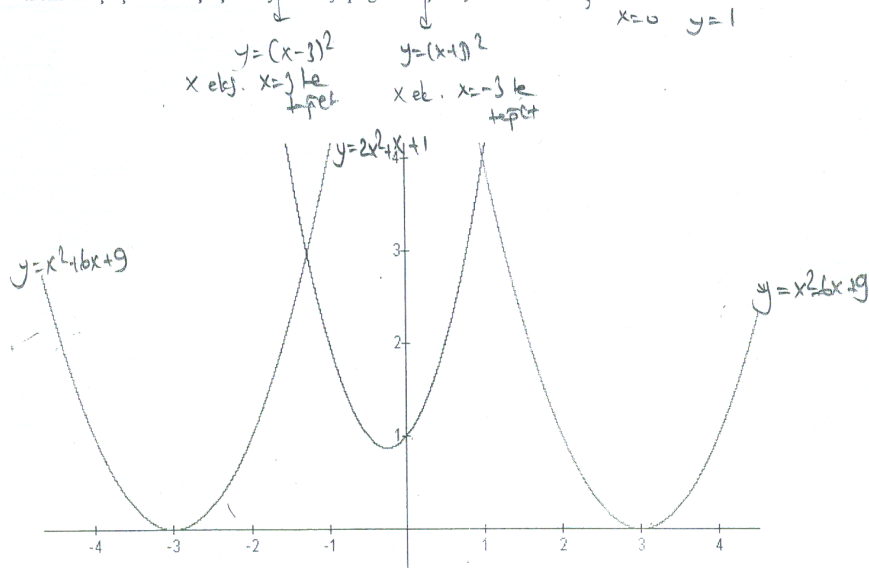


Figure 4.5 Continued



**Sixth Item:**

Sixth item can be considered as a combination of all items. It assesses all type of quadratic equation graphics. Students could use variety of strategies to match the given items with corresponding graphics. There are seven sub-questions that students needed to use all of the knowledge that they learn to find the correct choice. Comparing both groups, the control group tried to draw all of the questions one by one and after drawing four or five them they got bored and matched the remaining graphics without any calculation or drawing. And they matched the wrong graphics with wrong equation. However, considering the experiment group students, they drew one or two graphics and matched the other graphics by translation or constructing table for x and y pairs.

**Seventh Item:**

With the seventh item students are no longer expected to draw graph instead they are expected to interpret the items. The seventh item gives the graph and asks for the question “translation from graph to equation” that the students have more difficulty comparing to “translation from equation to graph”. Most of the students had difficulty to choose the correct equation in the pre-test. However, after the treatment, most of them were able to find the corresponding equation. But in the delayed post-test, the number of control group students who found the correct answer were decreased more compared to the experiment group. The related frequencies and percentages for the item seven is given in Table 4.16.

The control group students mostly draw all of the choices one by one. The rest of the control group gave zero to x for each of the answers. Also, two of the students write  $ax^2+bx+c$  and give -1, 0 and 1 and found a, b and c coefficients and chose the correct choice. On the other hand, ten of the control group students used  $x^2$  graph to find the desired equation. They translated the graph one unit down and found the correct choice. The rest of them preferred to use intersection points, they firstly utilized the y-intercept to find c coefficient. They explained that since graph passes -1 it must have 1 for a constant and eliminated “a” and “d” choices. Then gave 1 and -1 for the remaining choices and chose the correct choice.

**Table 4.16** Frequencies and percentages for the seventh item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	20(60.6)	9(27.3)	4(12.1)	31(96.6)	0(0)	1(3.1)
POSTGAT	1(3.0)	14(42.4)	18(54.5)	7(21.9)	8(25.0)	17(53.1)
DPGAT	8(24.2)	11(33.3)	14(42.4)	4(12.5)	18(56.2)	10(31.2)

**Eighth Item:**

This item assesses the same knowledge as item seven. However it is more difficult since the graph does not cross the x-axis and students cannot easily eliminate the choices. The corresponding frequencies and percentages are given in the Table 4.17.

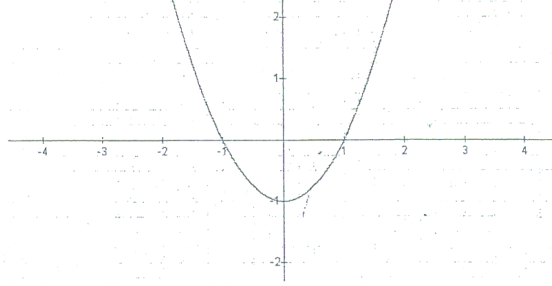
**Table 4.17** Frequencies and percentages for the eighth item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	31(92.9)	1(3.0)	1(3.0)	31(96.6)	1(3.1)	0(0)
POSTGAT	18(54.5)	14(42.4)	1(3.0)	7(21.9)	8(25.0)	17(53.1)
DPGAT	25(75.8)	8(24.2)	0(0)	4(12.5)	17(53.1)	10(31.2)

Considering the table, this is the question that most students had difficulty to find the correct answer. The control group students mostly choose the “a” and this is the wrong choice. They can easily eliminate the “b, c” and “e” choices because their constants are -1, and the graph passes +1 on the y-axis. After eliminating these choices, they chose one of the choices between a and d. Most of them choose “a” because it’s more familiar to the students; they did not think on the effect of leading coefficient. On the other hand, like control group, experiment group eliminated “b”, “c” and “e” choices. But after that, most of them compared the given graph with the seventh item, and concluded that since the graph is closer to the y-axis, the leading coefficient need to be larger than zero. Also seven of them picked points on the given graph and tried choices to find the corresponding one.

Two students’ answers from control and experiment group for the item seven and eight is given in the figure 4.5. Most of the control group students like given in the following figure did not make explanation and choose a choice. On the other hand, the experiment group student translated the given graph and found the desired graphics.

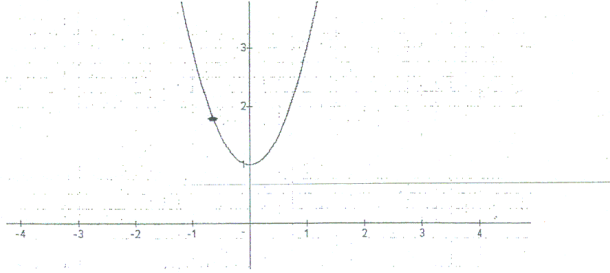
Soru7:



Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $x^2-1$
- C)  $-x^2-1$
- D)  $-x^2+1$
- E)  $2x^2-1$

Soru8:

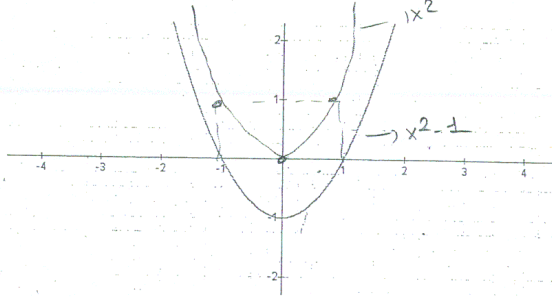


Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $-2x^2-1$
- C)  $-2x^2+1$
- D)  $2x^2+1$
- E)  $2x^2-1$

Figure 4.6 Students' responses for item seven and eight.

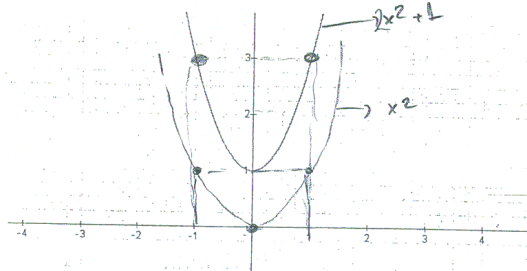
Soru7:



Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $x^2-1$
- C)  $-x^2-1$
- D)  $-x^2+1$
- E)  $2x^2-1$

Soru8:



Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $-2x^2-1$
- C)  $-2x^2+1$
- D)  $2x^2+1$
- E)  $2x^2-1$

Figure 4.6 Continued.

**Ninth Item:**

Ninth item is a multiple choice and examine students' knowledge about translation from table to graph. This is the item that control group students had difficulty to answer. Although they were able to fill tables in the first four questions, they could not answer this question correctly. The related percentages and frequencies are given in the Table 4.18.

**Table 4.18** Frequencies and percentages for the ninth item in the PREGAT, POSTGAT and DPGAT

---

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	31(92.9)	1(3.0)	1(3.0)	31(96.6)	1(3.1)	0(0)
POSTGAT	25(75.8)	7(21.2)	1(3.0)	7(21.9)	12(37.5)	13(40.6)
DPGAT	31(93.9)	2(6.1)	0(0)	3(9.4)	9(28.1)	20(62.5)

---

Considering the table, it could be concluded that the control group almost shows no improvement after the treatment. Although they used “tabular to graphic translation”, almost all of them passed over this question and some of them wrote that “I have no opinion how to draw this graph”. This is a surprising result for control group. The reason for this is that, considering the first item almost 95% of them could draw desired graphic by constructing table, and the ninth item examined the same knowledge; only the table was given, not the equation. So although they had the required knowledge they could not found the correct choice. On the other hand, the experiment group found correct choices, but almost half of them had difficulty to explain the correct choice. The rest of them had two different solutions for this item. Five of them marked the given x and y pairs on the coordinate system and drew the corresponding graph, then chose the correct

choice. Eight of them used the intersection points and tried to match them with the given graphics. After finding the correct choice they showed each of the given points on the graph.

**Tenth Item:**

This item assesses the students’ knowledge and skills in “translation graphical to tabular representation”. Students are expected to choose the correct x and y pairs from the given choices. Like the previous question, control group had difficulty to find the correct answer and the experiment group is more successful comparing to the control group. The related frequencies and percentages are given in the Table 4.19.

**Table 4.19** Frequencies and percentages for the tenth item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	33(100)	0(0)	0(0)	32(100)	0(0)	0(0)
POSTGAT	26(78.8)	6(18.2)	1(3.0)	6(18.8)	15(46.9)	11(46.9)
DPGAT	31(93.9)	2(6.1)	0(0)	4(12.5)	7(21.9)	21(65.6)

The control group students had difficulty to interpret the graph. They could not relate the graph with the table. The experiment group students had two solution strategies to find the correct answer. Eight of the students found the equation of the given parabola then gave the x values from the tables and chose the matching table. As another solution strategy, they used intersection points of the given parabola and eliminate “b” and “c” choices. After that they found corresponding x and y values from the graph and chose the correct table.

Considering the ninth and tenth question they are the mirror views of each other and control group students had difficulty to find a solution. This shows that although they have the knowledge of construction of table and drawing graph from it, they have difficulty to adapt this knowledge on other forms of the questions that assess the same knowledge.

**Eleventh Item:**

This item examines the students' knowledge about the translation of given graph for the desired unit on the x, y or both axes. The graph is given and asked to translate 1 unit right. This is a trap question that if students do not have enough knowledge they directly add 1 to the given  $x^2$  graph. The related frequencies and percentages are given in the Table 4.20.

**Table 4.20** Frequencies and percentages for the eleventh item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	29(87.9)	4(12.1)	0(0)	31(96.9)	1(3.1)	0(0)
POSTGAT	24(72.7)	6(18.2)	1(3.0)	6(18.8)	9(28.1)	17(53.1)
DPGAT	27(81.8)	5(15.2)	1 (3.0)	2(6.2)	6(18.8)	24(75.0)

Considering the table, most of the control group students could not find the correct answer. Mostly they chose wrong choice that is expected as they directly add the given unit. On the other hand, eleven of the experiment group students translated the given graph one unit right and drew the desired graph. After that,



they write explanations such as “If we move the graph one unit this means that we need to add one unit from the x. then the equation becomes  $(x-1)^2$ ”.

**Twelfth Item:**

This item, like eleventh, examines translation of given graph one unit upwards. Since the translation is on the y-axis, students are expected to subtract one unit from the given equation. However, as the given equation is  $x^2+x$ , students had difficulty to translate the given equation. This can be concluded from the control group students’ papers that as they wrote “if the graph is  $x^2$ , I can add 1, but x is confusing shall I add x or subtract, or does it change the sign, I do not know the answer.” Also some of them explained more by writing that “but if I can add 1, what is the answer of the eleventh question, this is different but I do not have clear idea about this adding or subtracting on the different axis”. On the other hand, experiment group followed the same strategy as they did on item eleven. They shifted the graph one unit upwards and found the corresponding equation, or explained how the equation changes by moving on the axis. They wrote that “ if we move the graph on the y axis, the constant changes such that if we move the graph up, then we add given unit, but if the graph moves down then we subtract given unit.” The related frequencies and percentages are given in the following Table 4.21.

**Table 4.21** Frequencies and percentages for the twelfth item in the PREGAT, POSTGAT and DPGAT

Scores	Control Group			Experimental Group		
	0	1	2	0	1	2
PREGAT	29(87.9)	4(12.1)	0(0)	32(100)	0(0)	0(0)
POSTGAT	25(75.8)	5(15.2)	3(9.1)	8(25.0)	16(50.0)	8(25.0)
DPGAT	27(81.8)	5(15.2)	1 (3.0)	5(15.6)	11(34.4)	16(50.0)

Considering table, almost same scores are obtained as item eleven. Control group hardly answered the question; they mostly left the question blank. On the other hand, experiment group had higher rate of success. As far as the last two item concerned, control group students had difficulty to translate the given graph and equation.

**Thirteenth Item:**

Thirteenth question assesses the students' knowledge of formulization. It is expected from students to find the symmetry axis of given quadratic equation using the formula  $-b/2a$ . And then using this value, students are expected to find the peak point by replacing the x values with the value that they find from the  $-b/2a$ . So, if students know the formula, then they could find the desired peak point and symmetry axis. Therefore almost all of the students in both groups correctly answered the question. There are just a few students remembering the formula as  $b/2a$  or  $-b/a$ , so were not able to find the correct answer.

**Fourteenth Item:**

Since almost all of the students know how to find peak point from given equation, this item is intended to observe students' knowledge whether they know the meaning of it. So, students are expected to find the peak point from the given graph. Two graphics are given to observe the changes in graphics whether it looks upward or downward. In the pre-test, none of the experiment group students were able to solve the question. However, after the treatment, they increased their success and almost all of them answered the question correctly. For the control group, except only one student, none of them did the question in the pre-test. After the treatment almost half of them answered the item correctly and the remaining half could not find the desired point. This shows that although they can apply the formula, half of the control group students did not know how to find it in the given graphic and so they do not know what the peak point means. Two of the students' responses from control and experiment group are given in the figure 4.7.

Soru13: Aşağıda verilen parabollerin tepe noktasını (simetri eksenini) bulunuz.

a)  $y=x^2+3x$

$$\frac{-b}{2a} = \frac{-3}{2}$$

b)  $y=x^2-2x+4$

$$\frac{2}{2} = 1$$

c)  $y=2x^2+x-4$

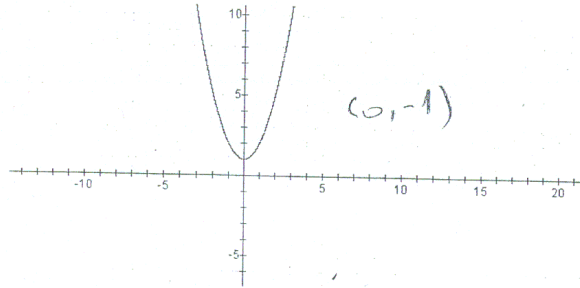
$$\frac{-1}{4}$$

d)  $y=-2x^2+4x-3$

$$\frac{-4}{-4} = 1$$

Soru 14: Aşağıda grafiği verilen parabollerin tepe noktasını bulunuz.

a)



b)

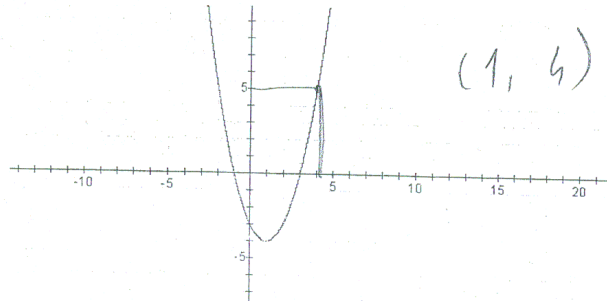


Figure 4.7 Students' responses for the item thirteen and fourteen

Soru 13: Aşağıda verilen parabollerin tepe noktasını (simetri eksenini) bulunuz.

$$T.N. = -\frac{b}{2a} \quad f$$

a)  $y = x^2 + 3x$   
 $a = 1, b = 3$   
 $x = -\frac{3}{2}$   
 $y = f\left(-\frac{3}{2}\right) = \left(-\frac{3}{2}\right)^2 + 3\left(-\frac{3}{2}\right)$   
 $T.N. = \left(-\frac{3}{2}, \frac{15}{4}\right)$

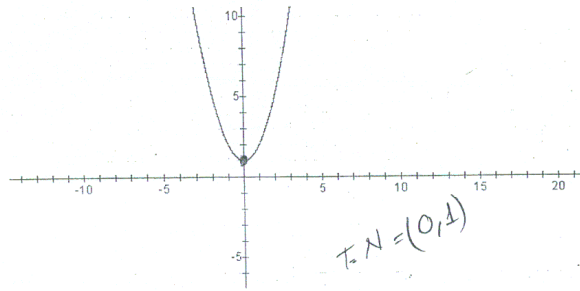
b)  $y = x^2 - 2x + 4$   
 $a = 1, b = -2, c = 4$   
 $x = \frac{2}{2} = 1$   
 $f(1) = (1)^2 - 2(1) + 4$   
 $= 1 - 2 + 4$   
 $= 3$   
 $T.N.$

c)  $y = 2x^2 + x - 4$   
 $a = 2, b = 1, c = -4$   
 $x = -\frac{1}{2}$   
 $y = f\left(-\frac{1}{2}\right) = \left(-\frac{1}{2}\right)^2 + \frac{1}{2}\left(-\frac{1}{2}\right) - 4$   
 $= \frac{1}{4} + \frac{2}{2} = \frac{15}{4}$   
 $T.N. = \left(-\frac{1}{2}, \frac{15}{4}\right)$

d)  $y = -2x^2 + 4x - 3$   
 $a = -2, b = 4, c = -3$   
 $x = -\frac{4}{-4} = 1$   
 $y = f(1) = (-1)^2 + 4(-1) - 3$   
 $= 1 - 4 - 3$   
 $= -6$   
 $T.N. = (1, -6)$

Soru 14: Aşağıda grafiği verilen parabollerin tepe noktasını bulunuz.

a)



b)

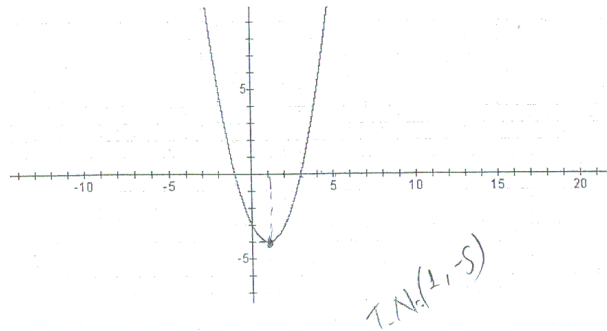


Figure 4.7 Continued

**Fifteenth Item:**

This item examines the students' knowledge of peak point like the item before. However students are expected to find the graph that match the given peak point. Percentages of control group students that answer the question correct are lower than the item fourteen. They had more difficult to find the desired peak point on the given graphics. However, the experiment group students are more successful and almost all of them gave the correct answer.

Concerning the entire GAT, both groups of students are successful for the questions that have steps to follow or formula, and experiment group is also successful for the question that involves translation and interpretation.

**4.3.2 Results of the Interview**

The first question was asked to be sure that students did not study at home before the treatment to get higher notes. And all of these six students reported that they did not study the subject before and they learned the graphics in the lessons. Also in the interview, three of the students (A, B, C) that had zero grade in the pre-test comment that they did not know the subject and even they did not have any idea about the quadratic equation and its graph. Another same response comes for all of the six students about the software program Nu-Calc, all of them found easy to use. Rest of the questions attempt to measure the students' opinion about the graphic concept, IWB and computer.

**4.3.2.1 Students' Views about the Graphics Concept**

The responses for the questions in the interview indicate some similarities concerning the graphics achievement of the students. All of the students developed positive feeling and attitude toward graphing concept after IWB used and they agreed that their explanation and reasoning skills improved. They can make comments and interpretations on the given problem about the second degree functions. Even considering the three low achieving students in the PREGAT, they improve their knowledge.

The student A explained his reasoning as; “Before taking the lesson, I did not guess even what look like a shape of a second degree function but after the lessons I can even visualize our drawing right now, when talking. Even I can explain now: the coefficient of  $x$  indicates the whether the parabola closer or far away to the  $y$ -axes and the constant coefficient shows the intercept point of  $y$  and the each unit that we add the  $x$  parabola change the place in  $x$ -axis. Moreover I learn the relation between the discriminant and the intercept point of the parabola. So in any question just by knowing this I believe that I can draw any graph without calculation and in the test I can choose correct answer so I am not afraid now when seeing a graphic in the test”.

Even one the student explained her reasoning by using her hand as a shape of parabola and moving her hand with the coefficient changes (D). She is so enthusiastic about describing the shapes. While talking about the reasoning skills of students two of them explained that also apply their knowledge on various graphics other than second degree functions. They also solve the graphic problems with first and third degree and also some special function like absolute value if they know the properties of the function (D, E).

Besides these, student F emphasized that “At first, I just think that the graphic concept consist of giving an algebraic expression and drawing it and vice versa. However after the lesson I learned that I spent too much time to draw the graph and if I could not find the intercept points I give up drawing and if the question asked for the writing the equation for the parabola I always use the choices and draw its graph whether it suits with the asked one. However I learned that drawing includes more than this knowledge. Now I can use different representations; table, graph, algebraic to find the correct answer. I can easily translate among different mode of representations. This takes less time and even sometimes I can find the correct choice without writing or calculating anything. Concerning the students’ responses, they all agree that their knowledge on graphics improved and they find a lot easier to draw the graph after the lesson.

#### 4.3.2.2 Students' Views about the IWB

The questions about the IWB attend to measure:

- Whether IWB create a difference in learning
- How IWB changes your opinion about mathematics and technology
- What are the advantageous and disadvantageous of using IWB

After using IWB, students find doing mathematics more interesting (n=4) and fun (n=5). Also students mostly mention about the visualization (n=6), efficiency and saving time for discussion and examples (n=5). Except for one student (B), the others had positive comment on IWB. The student B said that: "IWB is good only saving times. Since I do not have to write down all the things on the board I have more time to solve more examples. Other than that I do not think that IWB helps me to understand better. Because I cannot easily understand in the class, in order to understand I need to study by myself, I need to apply what I learn". After asking the reasons for this, the student explained that the computer helps a lot more by drawing and translation; he can study alone so that think more on examples and connect them with the lesson. So in a way, student benefits more from computer than IWB. When asking his feeling and attitude toward mathematics and IWB technology he concluded that the computer had more positive effect on him but IWB made the lessons more interesting.

On the opposite side one of the students (C) insisted on using the IWB in every lesson. She said that "I cannot imagine a lesson without the IWB. It is great because the teacher notes reflected on the board and we have the copies so we have time for more examples, for more talking and especially we talked why and what if questions that help me improve my learning. On the other lessons we try to write down the board, and if we late we pass the example without understanding. Also I can say about the IWB that especially I love most using different colors in drawings of graphics. Seeing different graph with different colors in one coordinate system is helped to understand the correlation between coefficients and the graphics." Also she explained her feeling by saying that: "Now I start to like mathematics, before using the IWB, I seat back part of the classroom and do not

want teacher to ask me any question, I just listen to the teacher without thinking. But now, the IWB makes me think about the lesson because I start to have fun and that makes me interested in the lesson. And I found myself waiting for another question, checking my answers. I think the IWB motivates me in the lesson.”

Concerning the answer of students A, D, E, F, they have positive attitude toward the IWB. They like most about the solving more questions and about not writing down all notes from the board. And the student C added that “IWB improve my concept knowledge by repeating the lesson done before. Since I am lazy, I do not want to go back the previous lesson, but in the lesson teacher remind what we learned before so this helps me learn and remember the subject and questions. If the blackboard was used when the information on it erased they are gone, but IWB keeps them.” Also their feeling about the mathematics and IWB are positive. They said that before using the IWB they are undecided about the IWB. But in the lessons they have more fun and they try to actively involves in the lesson. And when they start to understand they start to like the mathematics (A, C, D, E, F)

#### **4.3.2.3 Students’ View about the Computer**

The purpose of the questions about the computer use and computer program Nu-  
Calc was

- To get the students opinion for the activities.
- To get the students opinion about mathematics and computer
- To understand the advantageous and disadvantageous of computer use.

After using computers, students find drawing graphics quicker (n=4) and joyful (n=3). Also they mention about the visualization (n=3), immediate feedback (n=3). The first question about the computer technology is about the software itself: whether it is easy to use or any difficulties that the students encounter since in the PREATTTS, some students indicate that they have difficulties with computer. All of the six students find very easy to use the software and student A said that “anyone who can type the equation and press the enter key can use the program, there is no need to know anything about the computer itself.” However in the computer session a couple students had difficulty entering the correct formula if the formula includes bracelets. But they whether want help or enter the equation again.



The question about the activities involves; drawing graph, drawing multiple graphics, seeing algebraic expression in the graphic forms. Each of the students emphasized that they love the drawing a graph in a moment. Student B said that: “drawing a graph by one click is amazing. After a couple of question before I push the enter key, I tried to visualize the shape of the equation: where it pass, downward or upward, intercept points and after a couple of try a lot of time I guess the correct shape. This was wonderful for me because at first I do not know what a parabola looks like but now I can draw them in my mind. This will be very help full for me while selecting the correct equation and correct graph”. But after asking the second activity they said that drawing multiple graphics can help them especially in translation problems. Moreover while talking these activities; the students B, C, E, F also added the animation activity. “After drawing multiple graphics, the animations strengthen the translation but especially it helps to understand the coefficient change”. And for the last question the student A said that “I do not need to imagine anything, the computer visualizes every graph and visualization helps me learn.”

Concerning the attitudes and feeling of students’, each of them concluded that they are very happy to learn the subject with computer. The student B concluded that “I am very enthusiastic when seating in front of a computer, checking my own answers, interpreting my graphics results. I like to do the lesson by myself because I learn more and easier. It arouses my curiosity, I try to guess the next step, and I see all representation modes at one page. Comparing with IWB and computer, computer increases my learning a lot more. I can think more clearly when I use a computer to do mathematics and I want to do more graphics using computer”. And the student C comment is “when I first seat in front of the computer, it scares me a lot because I do not know anything about computers. It looks so complicated until the teacher explains the first example. And before the activities, we practice the graphics and after this work I feel comfortable using computer. I enjoy drawing graphics at computer. And it makes mathematics more interesting and joyful”.

## CHAPTER 5

### DISCUSSION, CONCLUSION AND IMPLICATIONS

The purpose of this study was to examine the effects of technology based treatment on art and literature graduated students for achievement of graphics concept, attitude towards mathematics and attitude towards technology that they used. Therefore in this section, the discussion and conclusion for the obtained data are given with respect to the variables explained below. These are followed by recommendation for further research.

#### 5.1 Students' Performance in Graphics

The effect of the treatment on graphic concept was investigated by comparing mean scores of control and experimental group students. PREGAT results showed that there is no significant mean difference between experiment and control group. Therefore both groups were equivalent in terms of their quadratic equation and their graphics knowledge at the beginning of the treatment. POSTGAT results showed that both control and experiment groups improved their achievement in drawing and interpreting quadratic equation and their graphics. However, when examining the students GAT items, it is seen that students in different group had different solution strategies. When examining students' solution strategies, considering first three items it could be concluded that the control group students are good at drawing graphics from equations, they follow the steps given in the lessons. However considering the items four, seven, eight, nine and ten, it could be concluded that they hardly combine other knowledge like discriminant, symmetry axis, coefficients and etc. On the other hand, experiment group is also good at drawing graphics considering the first three items. However, besides drawing graphics step by step, they also use translation, coefficient of functions, discriminant, and symmetry axis for the items six, seven, eight, nine and ten. In the post-tests, experiment group did not depend on the step by step solution; they used

translation among graphic, tabular and algebraic forms, also they used coefficient effects on the graphics, properties of quadratic equations like discriminant and symmetry axis. They made explanation about the graphics that they draw. This shows that experiment group students use critical properties and their understanding was deeper. Besides the difference in solution strategies, experiment group students did better in interpretation questions. Interpretation questions involve classification and translation tasks. Considering both groups of students' scores in GAT, control group students were less successful. They were hardly answering the questions. As emphasized by Leinhardt, Zaslavsky and Stein 1990, the major difficulty for the students of all ages is the translation between algebraic, graphical and tabular representations. Students find it very hard to understand relationship and translate among representations because each representation and translation among them requires different psychological process. For example, mostly in the problems, translations from equation to graphics and from graphics to equation are required. Concerning these two translations, movement from graphics to their equation would be a more difficult task because it involves pattern detection. On the other hand, graphing an equation consists of steps; finding ordered pairs, plotting them on coordinate system and drawing the equation. If the question is about drawing graphics from the algebraic form, students follow the steps mentioned before, and draw the graphics but if the question involves giving the parabola and finding the equation students have more difficulty and if this is an item matching question, students check for the equations, they do not attempt to move graphics to equation. Considering the item results and students' strategies for solution of each item, control group students mostly solved the questions step by step and used translation equation from graphics. If the question involves translation graphics from equation they drew each of the choices. This conclusion had some similarities as Barton (1997) study. He also found that the group that used technology made more connections with their previous knowledge and used explanations and made predictions compared with the control group.

The reason for this difference would be the visualization. As emphasized by Archavi and Hadas (2000), technological environment supports visualization and experimentation. The IWB create an environment that students can visualize the graphics together in all three forms. Students see the changes in graphics by changing coefficients and this helps them visualize the translation of graphics to desired units (especially the animation and drawing multiple graphics) and interpret the changes of coefficients on graphics. This conclusion can be drawn from the students GAT results and interviews. On the other hand, in the control group the teacher drew graphics on the board and informed students about the properties and how to draw the graphics. Then like other class, the teacher drew multiple graphics in one coordinate to show the translation. However this is not enough students to develop their reasoning and interpretation skills. This can be concluded from the students' answers from questions that involve translation.

## **5.2 Students' Attitudes Towards IWB and Computer**

At the end of the treatment, an attitude scale was administered to the experiment group students to understand their attitudes toward IWB and computer. Interviews were conducted with six students to get their opinion about these technologies. Considering both and especially classroom observations, the conclusion can be drawn that students are enthusiastic about the use of the technology. Almost in every lesson, the students actively involved as asking questions, making connections from the knowledge that they learned before. However in the control group, students got bored after drawing couple of graphics and they thought that all the graphics are nearly the same. So, their reasoning and interpretation skills did not improve as much as experimental group. Considering the result of the interviews most of the students describe the IWB and computers as enjoyable, interesting and more fun. Before the treatment they are undecided or did not agree that IWB and computer can help them to learn mathematics. However, considering their attitude scale, they indicate that they concentrate better in class when IWB is used and also they indicate that interactive whiteboard and computer helps to learn mathematics better. Moreover considering the result of Hennessy, Fung and Scanlon (2001); they found that students developed a positive feeling and attitudes

after using the technology and students in their research emphasize that their self-confidence increased with the calculator use and more importantly students showed that the graphing calculator positively. Also similar results were reported by Glover and Miller (2001), Beaucamp (2004), Wood and Ashfield (2007).

#### Recommendations for Further Research:

Well trained teachers can use IWB to improve students' attitudes toward the lessons and mathematics, organize IWB lessons with assignments. Teacher use of IWB improves student achievement. In order to teacher achieve these; they need to be well trained. The trainings can be given in summer schools or workshops. Moreover the undergraduate teachers can take lessons on these issues. Authors can also mention the IWB and technology use in the books. They can give examples and activities in textbooks

Besides on the findings of this study, there is a number of future research is available. And among them are:

- Since in the study the number of students is limited to 32 and 33 for experiment and control group, the study could be conducted with more students. This is important to make more generalized conclusions.
- The study could be conducted with different concepts that visualization is less important like natural numbers or visualization more important like geometry, trigonometry. This is important to investigate if the technology is effective in different concepts.
- The study could be conducted over one academic year. This is important to investigate the students whether show the same motivation and interest toward the mathematics and technology.

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## APPENDIX A

### GRAPHIC ACHIEVEMENT TEST

Ad Soyad:

Soru1: Aşağıda verilen parabolleri çiziniz.

a)  $y=5x^2$

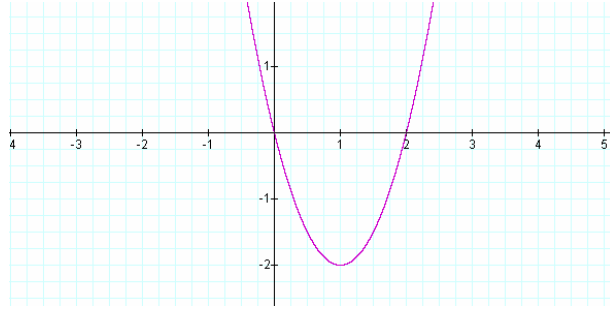
b)  $y=3x^2-27$

c)  $y=3x^2-2x+1$

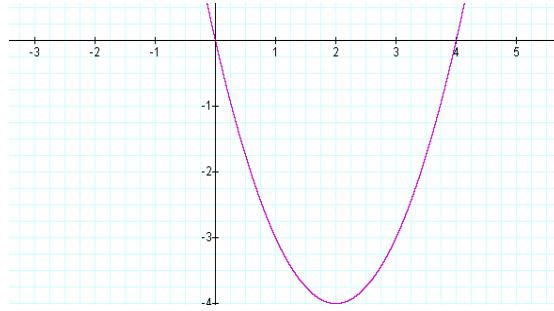
d)  $y=2x^2-4x-3$

Soru2: Aşağıdakilerden hangisi  $y=x^2-4x$  parabolüne ait olabilir? Neden?

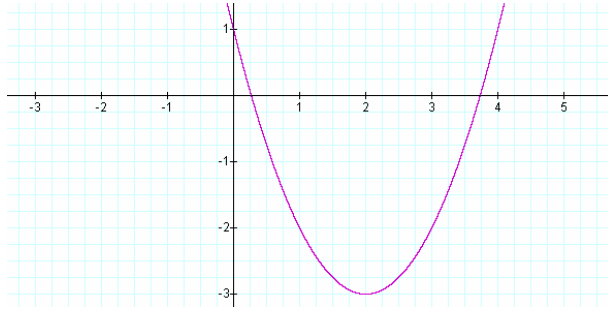
a)



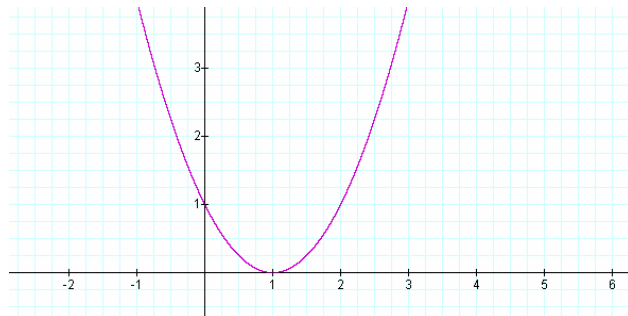
b)



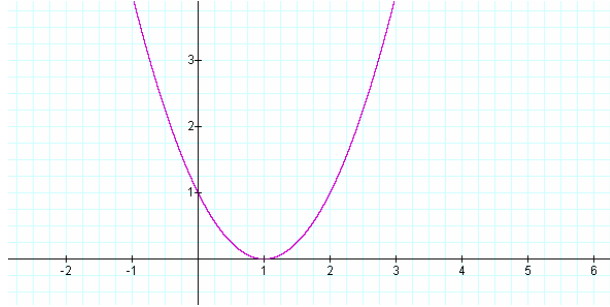
c)



d)

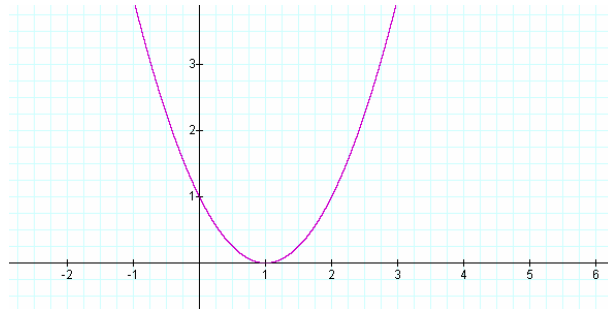


e)

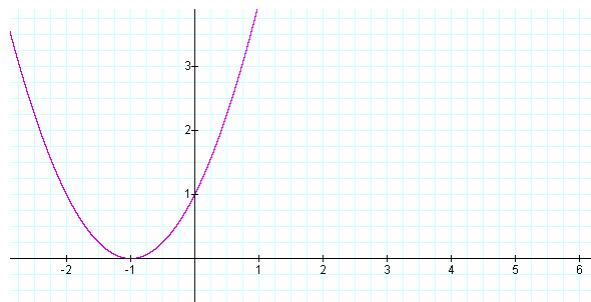


Soru3: Aşağıdakilerden hangisi  $y=x^2-2x+1$  parabolüne ait olabilir neden?

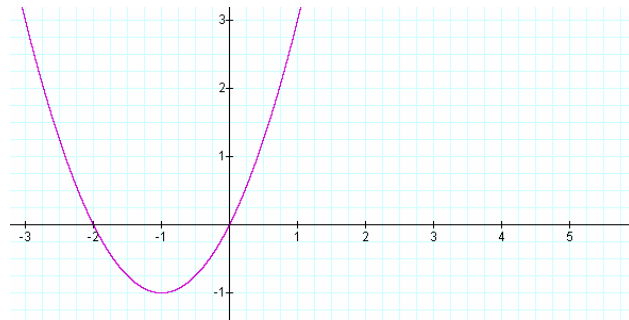
a)



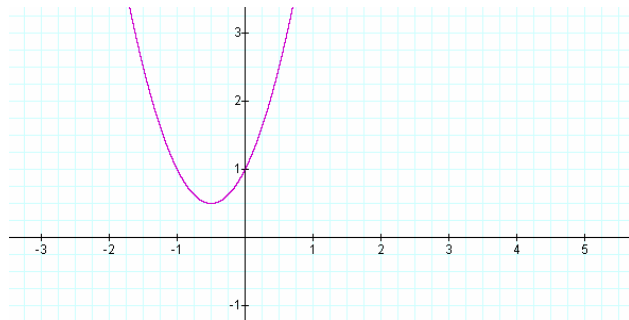
b)



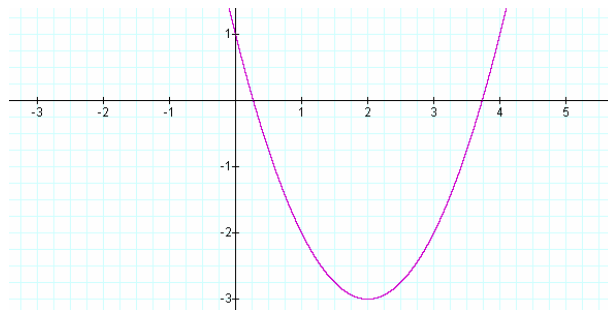
c)



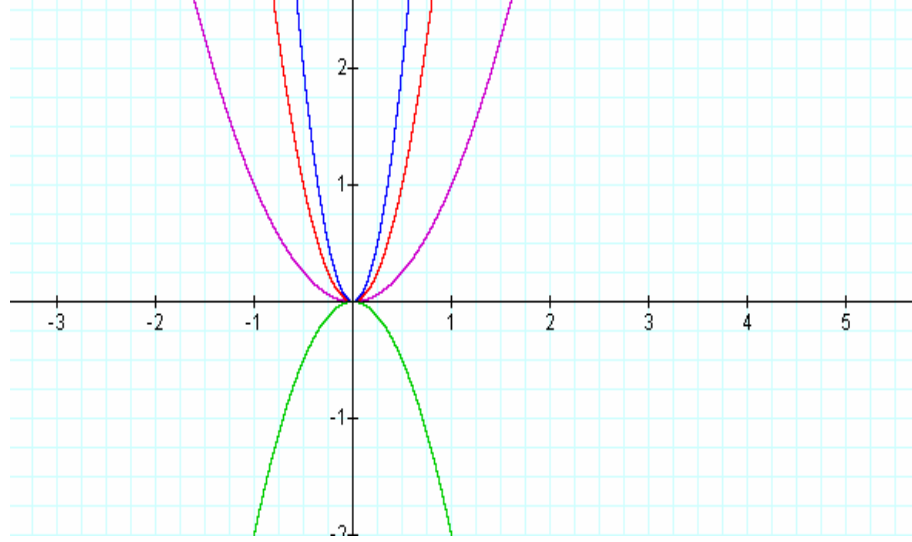
d)



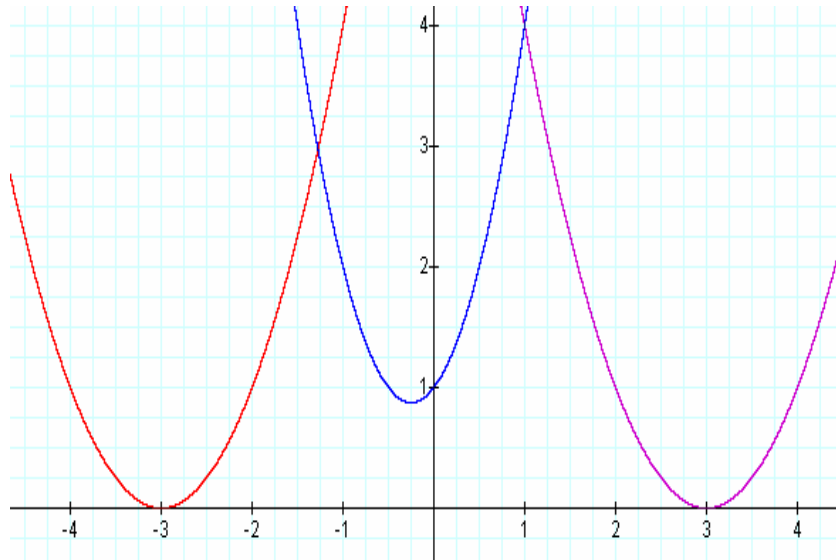
e)



Soru4: Aşağıdaki grafikler  $y=x^2$   $y=4x^2$   $y=8x^2$  ve  $y=-2x^2$  parabollerine aittir. Bunları eşleştiriniz. Eşleştirmeyi nasıl yaptığınızı açıklayın



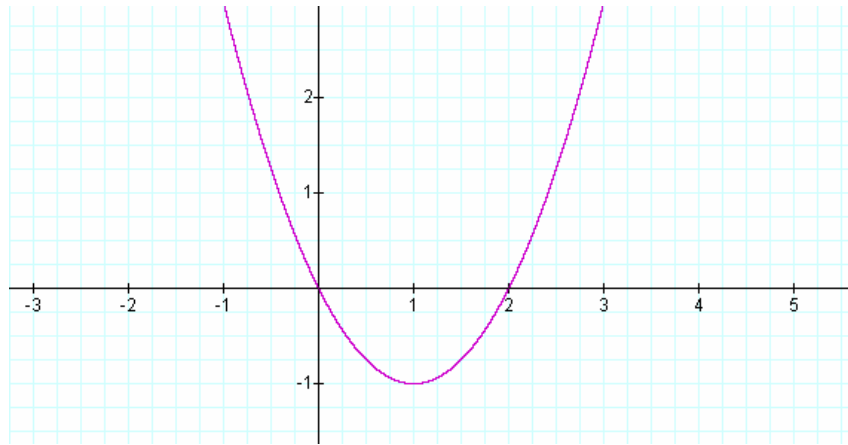
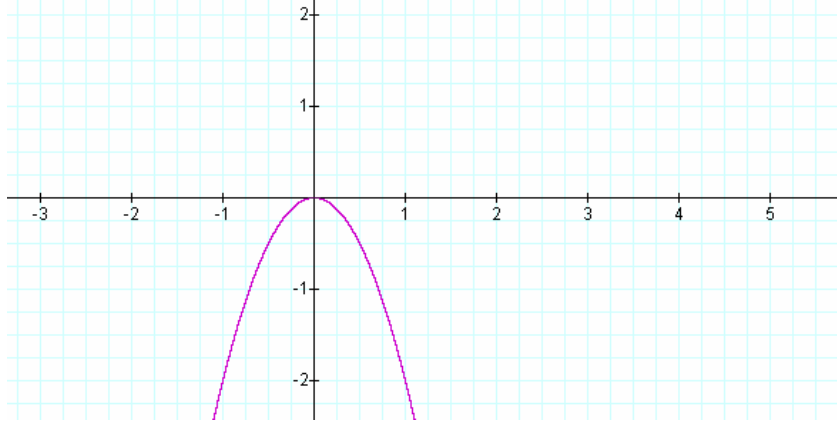
Soru5: Aşağıdaki grafikler  $y=x^2-6x+9$  ,  $y=x^2+6x+9$  ve  $y=2x^2+x+1$  parabollerine aittir. Bunları eşleştiriniz. Eşleştirmeyi nasıl yaptığınızı açıklayın



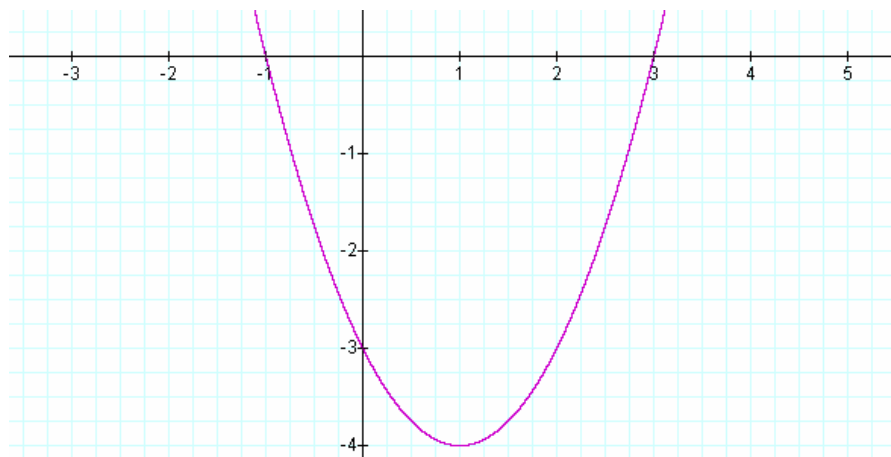
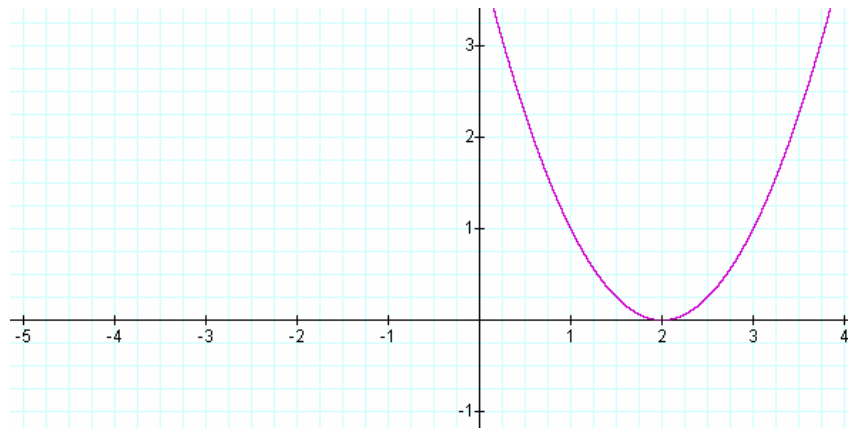
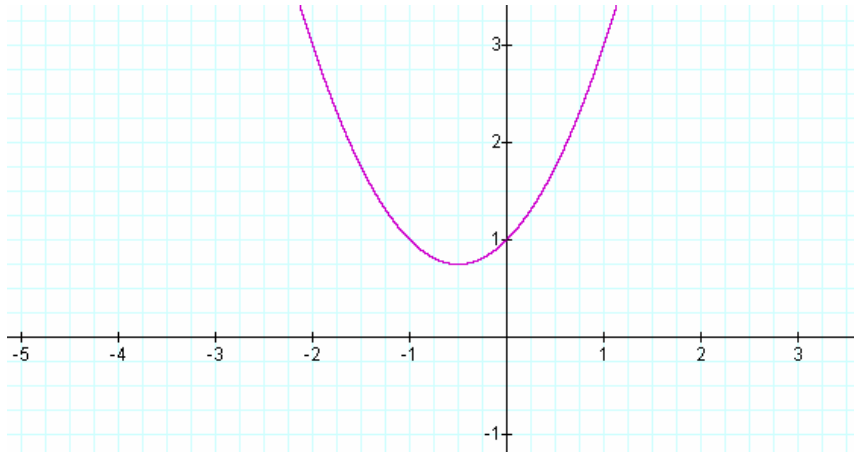
Soru6: Aşağıda verilen grafikleri ve denklemleri eşleştiriniz. Eşleştirmeyi nasıl yaptığınızı açıklayın.

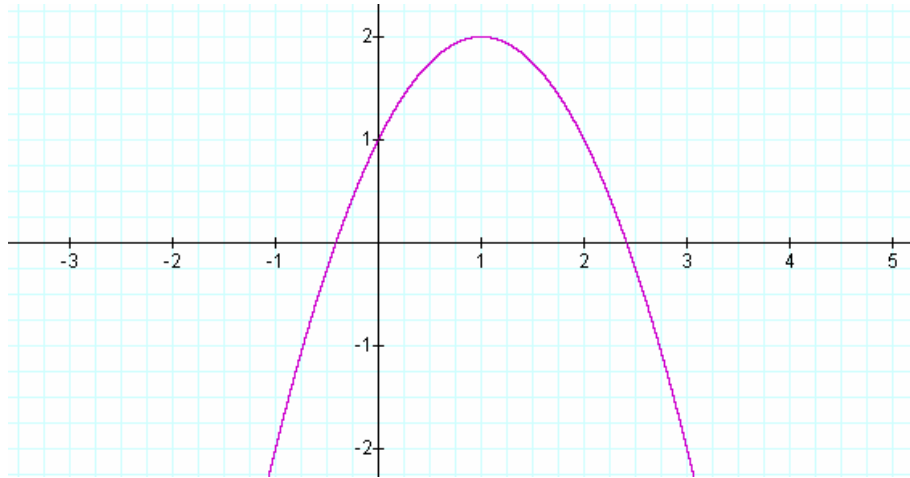
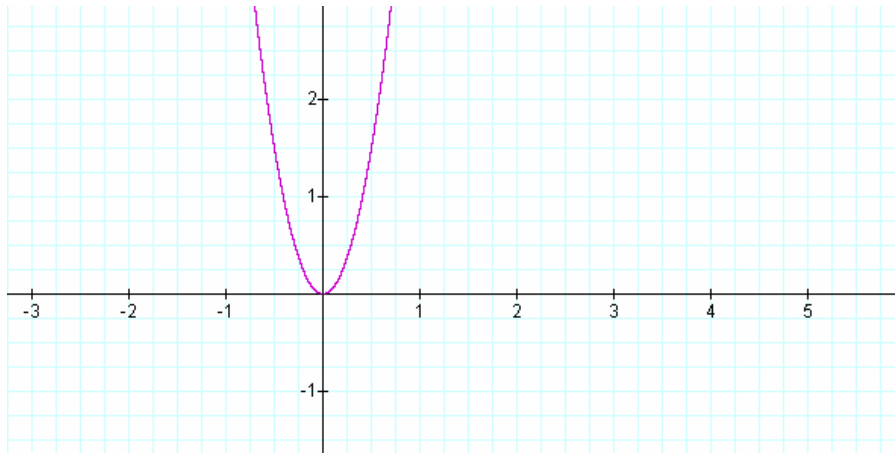
a)  $y=6x^2$       b)  $y=x^2-2x$       c)  $y=-2x^2$       d)  $y=x^2+x+1$       e)  $y=x^2-4x+4$       f)  $y=x^2-2x-3$

g)  $y=-x^2+2x+1$

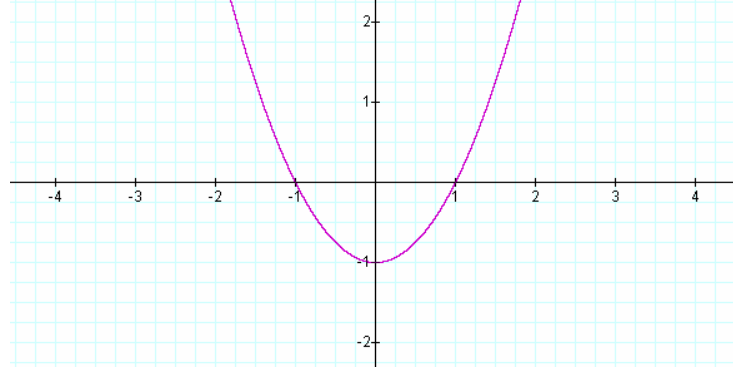








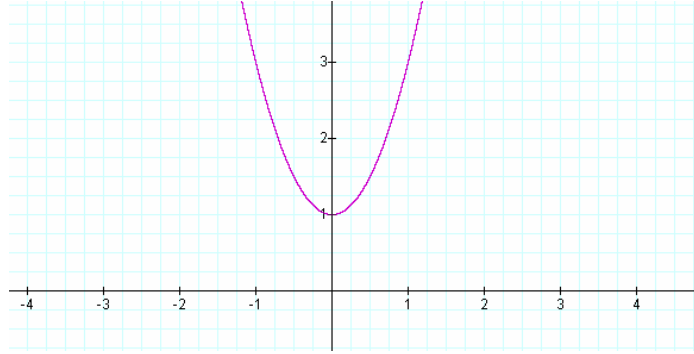
Soru7:



Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $x^2-1$
- C)  $-x^2-1$
- D)  $-x^2+1$
- E)  $2x^2-1$

Soru8:



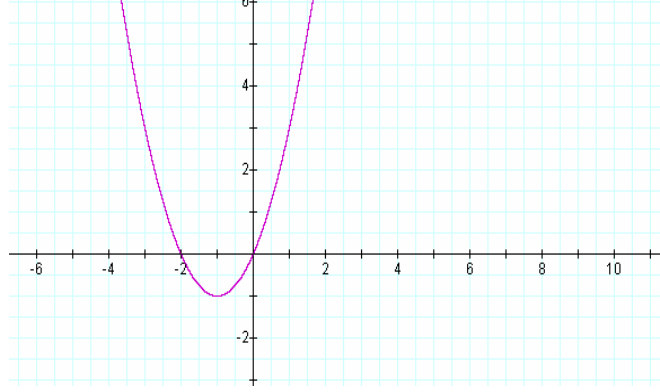
Aşağıdaki denklemlerden hangisi yukarıda verilen grafiğe at olabilir neden?

- A)  $x^2+1$
- B)  $-2x^2-1$
- C)  $-2x^2-1$
- D)  $2x^2+1$
- E)  $2x^2-1$

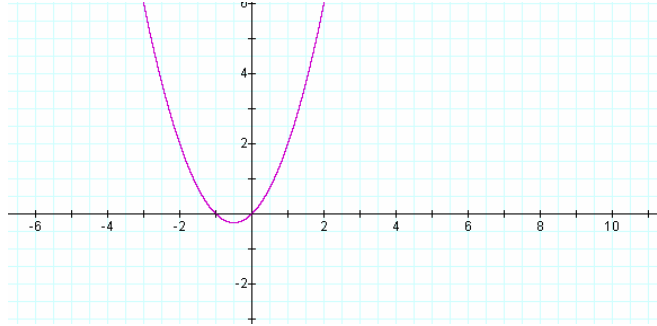
Soru9: Aşağıda verilen grafiklerden hangisi verilen tabloyu sağlar?

x	-1	0	1
y	0	0	2

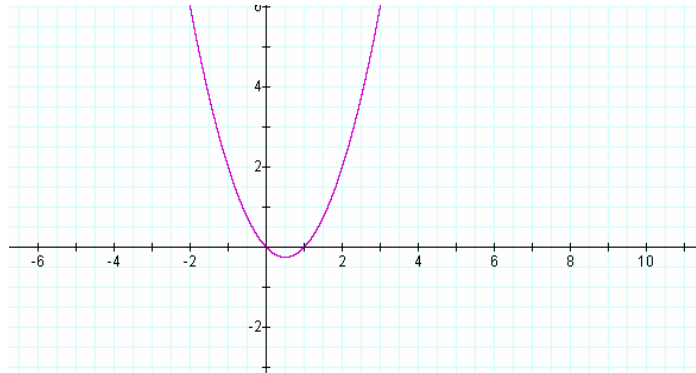
A)



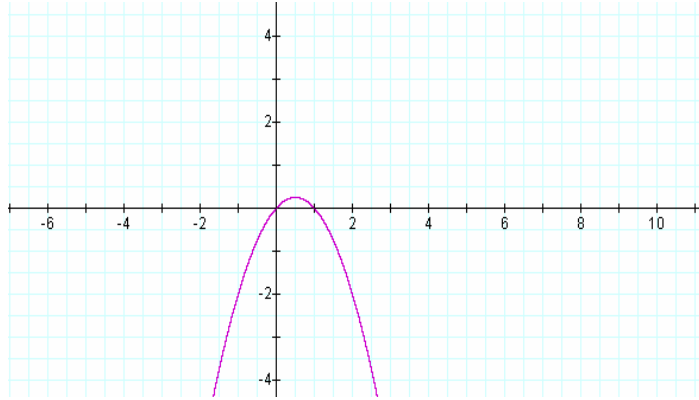
B)



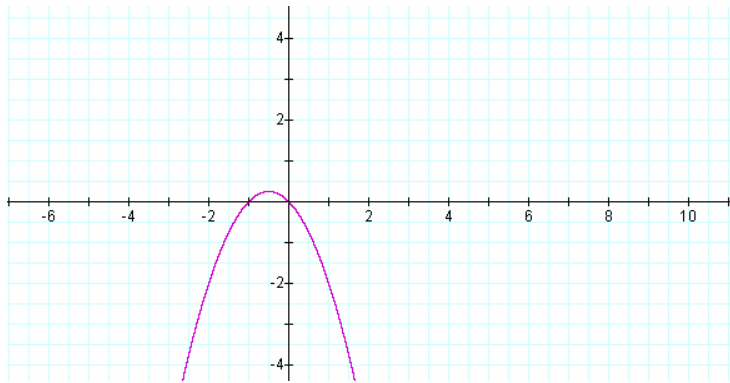
C)



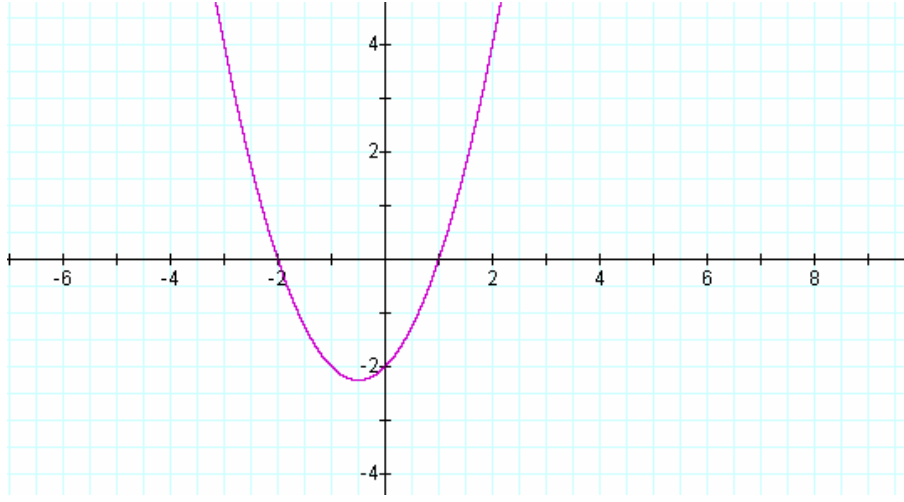
D)



E)



Soru10:



Yukarıda verilen grafik aşağıda verilen tablolardan hangisini sağlar?

A)

x	-1	0	1
y	-1	0	-2

B)

x	-1	0	1
y	-1	-2	0

C)

x	-1	0	1
y	-2	-1	0

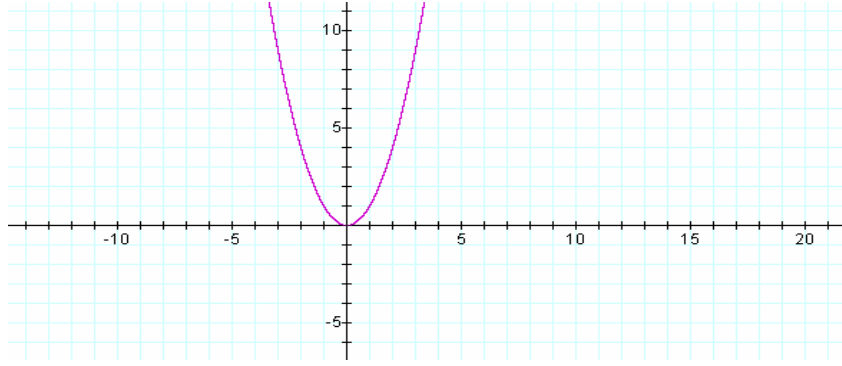
D)

x	-1	0	1
y	2	0	-2

E)

x	-1	0	1
y	-2	-2	0

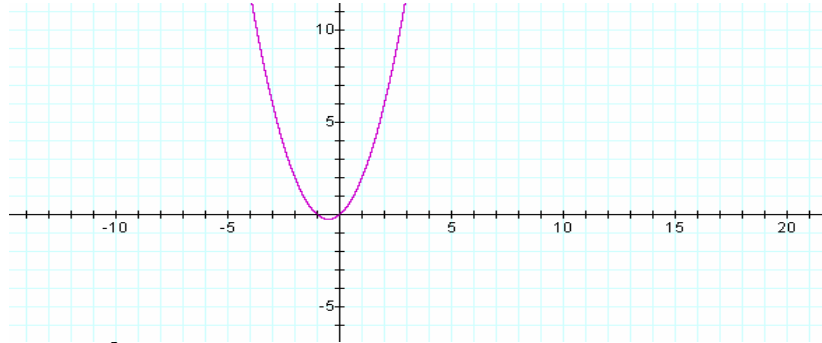
Soru11:



Şekilde  $y=x^2$  parabolünün grafiği verilmiştir. Grafik 1 birim sağa kaydırılırsa aşağıdaki denklemlerden hangisi elde edilir?

- A)  $y=x^2+1$
- B)  $y=x^2-1$
- C)  $y=(x-1)^2$
- D)  $y=(x+1)^2$
- E)  $y=x^2+x+1$

Soru12:



Şekilde  $y=x^2+x$  parabolünün grafiği verilmiştir. Grafik 1 birim yukarı kaydırılırsa aşağıdaki denklemlerden hangisi elde edilir?

- A)  $y=x^2+x+1$
- B)  $y=x^2-x+1$
- C)  $y=x^2+x-1$
- D)  $y=x^2+x$
- E)  $y=(x-1)^2$

Soru13: Aşağıda verilen parabollerin tepe noktasını (simetri eksenini) bulunuz.

a)  $y=x^2+3x$

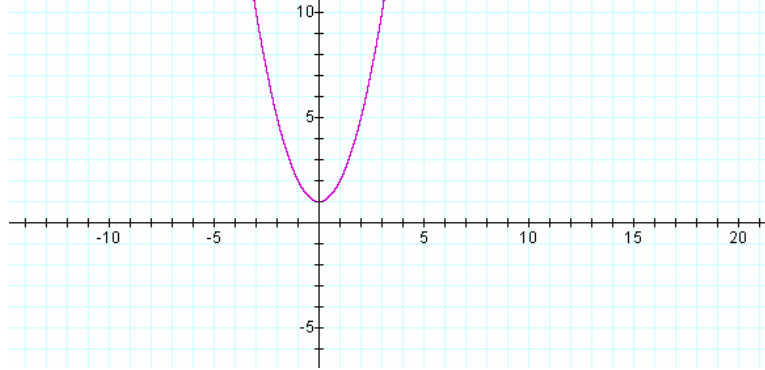
b)  $y=x^2-2x+4$

c)  $y=2x^2+x-4$

d)  $y=-2x^2+4x-3$

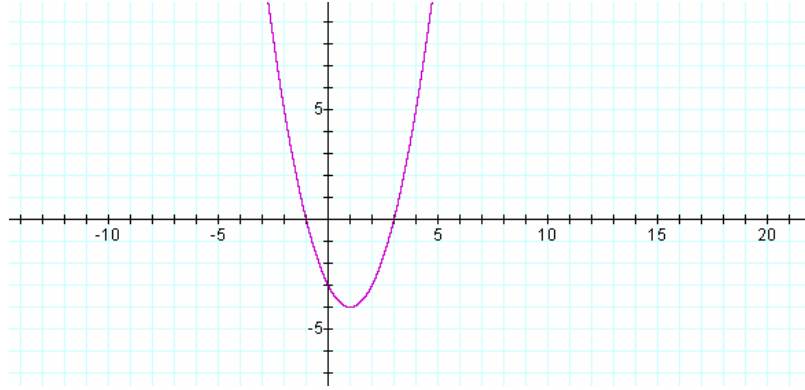
Soru 14: Aşağıda grafiği verilen parabollerin tepe noktasını bulunuz.

a)



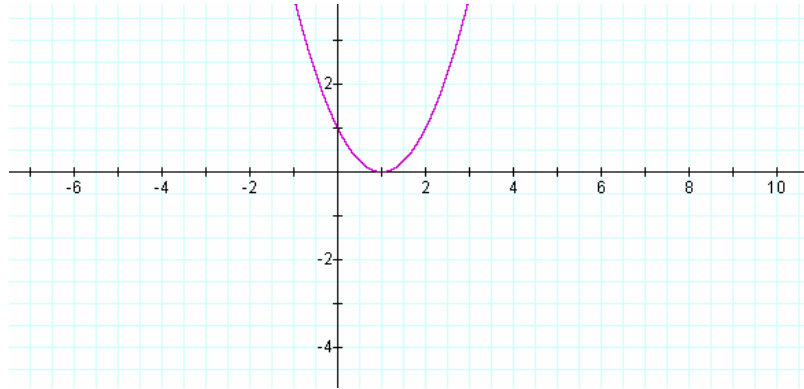


b)

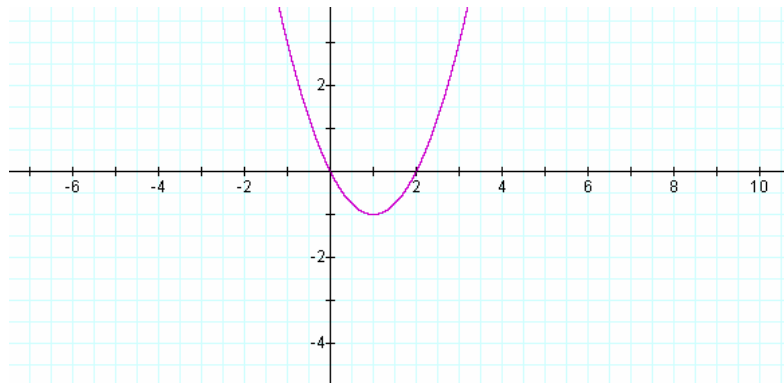


Soru15: Tepe noktası  $(-1,1)$  olan parabol aşağıdaki grafiklerden hangisine ait olabilir?

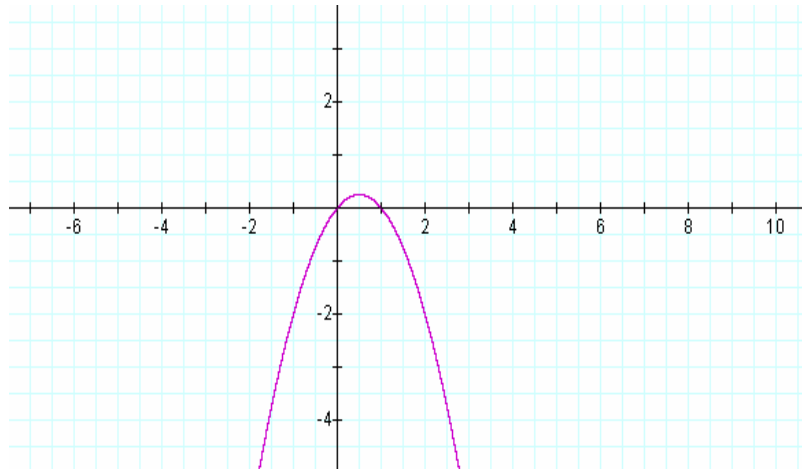
A)



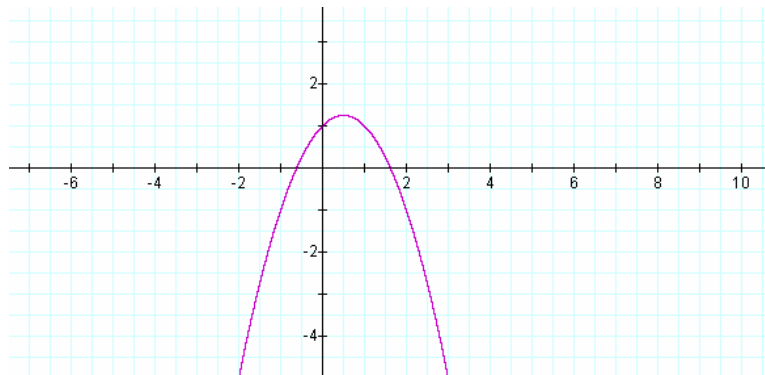
B)



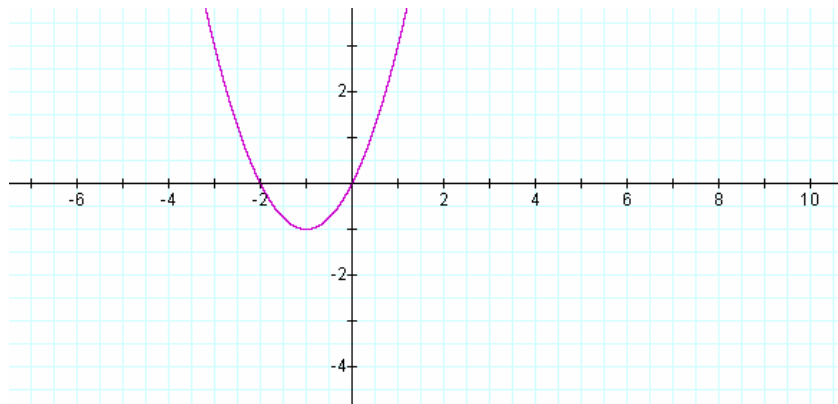
C)



D)



E)



## APPENDIX B

### ATTITUDE TOWARDS MATHEMATICS SCALE

Bu ölçek matematikle ilgili görüşlerinizi öğrenmek için 40 sorudan oluşmaktadır. Hiçbir sorunun ‘‘doğru ya da yanlış cevabı’ yoktur. Verilen kodlara göre her soruyu dikkatlice okuyup kendinizi en iyi anlatan kodu başına yazınız.

A-Kesinlikle katılmıyorum

B-Katılmıyorum

C-Kararsızım

D-Katılıyorum

E- Kesinlikle katılıyorum

1. Matematik gerekli ve zahmete değer bir konudur.
2. Matematik yeteneğimi geliştirmek istiyorum
3. Matematik problemlerini çözmekten büyük zevk alırım
4. Matematik akli geliştirir ve düşünmeyi öğretir.
5. Matematik günlük hayatta önemlidir
6. Matematik okunması gereken en önemli konulardandır
7. Gelecekte hangi konuyu çalışırsam çalışayım lisedeki matematik dersleri faydalı olacaktır
8. Matematiği okul dışındada kullanabilecek pek çok yer görebiliyorum
9. Matematik en çok korktuğum konulardandır
10. Matematik çalışırken aklım karışır ve net bir şekilde düşünemem
11. Matematik çalışmak kendimi gergin hissetmeme neden olur
12. Matematik kendimi rahatsız hissetmeme neden olur
13. Matematik dersinde kendimi her zaman çok gergin hissederim
14. Matematik sözcüğünü duyduğumda hoşlanmama hissi hissederim
15. Bir matematik problemi çözmek zorunda kalmayı düşünmek bile beni tedirgin yapar.

16. Matematik beni korkutmaz bile
17. Konu matematik olunca kendime çok güvenim olur.
18. Matematik problemlerini çok zorlanmadan çözebilirim
19. Girdiğim herhangi bir matematik dersinden iyi bir not alacağımı tahmin ediyorum
20. Matematik derslerinde her zaman aklım karışır
21. Matematik dersinde güvensizlik hissederim
22. Matematiği kolay öğrenirim
23. İleri matematik konularını kolayca öğrenebileceğime inanıyorum
24. Okulda matematik dersi almaktan genelde zevk alırım
25. Matematik boş ve sıkıcıdır
26. Yeni matematik sorularını çözmeyi severim
27. Matematik ödevi yapmayı kompozisyon yazmaya yeğlerim
28. Üniversitede matematiği kullanmayacağım bir alanda öğrenim görmek isterim
29. Matematiği gerçekten seviyorum
30. Matematik dersinde diğer derslerden daha mutluyum
31. Matematik çok ilginç bir konudur
32. Gereken matematik konularından daha fazlasını öğrenmeye niyetliyim
33. Eğitimim süresince alabileceğim bütün matematik derslerini alabilmeyi planlıyorum
34. Matematiğin meydan okuması beni çeker
35. Bence ileri matematik okumak faydalıdır
36. Matematik öğrenmenin diğer alanlarda ki problemleri çözmeye bana yardımcı olacağına inanıyorum
37. Karmaşık bir matematik probleminin çözüm yollarını araştırmak için kendi düşüncelerimi rahatlıkla açıklayabiliyorum
38. Matematik derslerinde soruları rahatlıkla cevaplayabiliyorum
39. İş hayatımda sağlam bir matematik bilgisi işime yarayacaktır
40. Matematik sorularını çözmeye iyi olduğuma inanırım

## APPENDIX C

### ATTITUDES TOWARD TECHNOLOGY SCALE

Adı , Soyadı : Sınıfı: No: Yaş :

#### Bilgisayar Destekli Matematik Eğitime Karşı Tutum Ölçeği

**Genel Açıklama:** Bu ölçek bir bilgi testi değildir ve bu nedenle hiçbir sorunun ‘‘doğru cevabı’’ yoktur. Aşağıda yer alan sorularla interaktif tahta ile yapmış olduğunuz dersleriniz hakkındaki fikirleriniz öğrenilmek istenmektedir. Verilen yargı cümlelerini okuyarak kendi düşüncenizi en iyi yansıtan yalnız bir seçeneği işaretleyiniz.

	Hemen hemen hiç	Ara sıra	Yaklaşık yarı yarıya	Genellikle	Hemen hemen her zaman
1. Matematikte bilgisayar ve interaktif tahta kullanıldığında daha zor konsantre olurum.					
2. Bilgisayar ve interaktif tahta kullanıldığında öğretmenin sorduğu sorulara cevap vermeye çalışırım.					
3. Matematik dersinde teknoloji kullanmak derse ilgimi artırıyor.					
4. Bilgisayarla öğrenirken eğer bir problemi çözmeyi başaramazsam, çözmek için başka fikirler denemeye devam ederim.					
5. Bilgisayar kullanmakta başarılıyım.					
6. VCR, VCD, DVD, MP3 ve cep telefonu gibi teknolojik aletleri kullanmakta başarılıyım.					
7. Birçok bilgisayar sorununu çözebilirim.					
8. Okul için gerekli olan herhangi bir bilgisayar programını iyice öğrenebilirim.					

	Kesinlikle katılmıyorum	Katılmıyorum	Emin değilim	Katılıyorum	Kesinlikle Katılıyorum
9. Bilgisayarla öğrenirken derse ilgimi artırdı.					
10. Bilgisayarla öğrenirken dersi daha iyi anlıyorum.					
11. İnteraktif tahtayla problemleri çözmek daha çekici.					
12. İnteraktif tahta matematiği daha iyi öğrenmeme yardım ediyor.					
13. İnteraktif tahtayla birçok şey öğrenebilirim.					
14. İnteraktif tahta kullanıldığında, öğrenmek için kullanılan zaman daha etkili ve fazla bir şekilde kullanılıyor.					
15. İnteraktif tahtayla kitaptan öğreneceğimden daha fazlasını öğreniyorum					
16. İnteraktif tahta kullanıldığında dersi daha iyi anlıyorum					
17. İnteraktif tahta kullanıldığında derse daha iyi konsantre oluyorum					
18. Matematikte interaktif tahtayı kullanmak, fazladan sarf edilen zaman, emek ve efora değer.					
19. İnteraktif tahtaya kullanıldığı zaman matematik daha ilginç hale geliyor.					
20. Matematik için interaktif tahtayı kullanmayı seviyorum.					

Hemen hemen hiç (HHH)  
Ara sıra (AS)  
Yaklaşık yarı yarıya (YYY)  
Genellikle (G)  
Hemen hemen her zaman (HHHZ)

Kesinlikle katılmıyorum (KKM)  
Katılmıyorum (KM)  
Kararsızım (KR)  
Katılıyorum (K)  
Kesinlikle katılıyorum (KK)