THE EFFECTS OF TEACHING LINEAR EQUATIONS WITH DYNAMIC MATHEMATICS SOFTWARE ON SEVENTH GRADE STUDENTS' ACHIEVEMENT

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ABSTRACT

THE EFFECTS OF TEACHING LINEAR EQUATIONS WITH DYNAMIC MATHEMATICS SOFTWARE ON SEVENTH GRADE STUDENTS' ACHIEVEMENT

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The purpose of this study was to investigate the effects of teaching linear equations with Dynamic Mathematics Software (GeoGebra) on seventh grade students' achievement compared to the regular instruction. *Randomized posttest-only control group design* was utilized in the study. 60 seventh grade students (32 girls and 28 boys) of a public school in Yenimahalle district in Ankara participated in the study. The study was conducted in 2011-2012 fall semester, lasting 9 class hours in three weeks. The data was collected by three Mathematics Achievement Tests: Cartesian coordinate system achievement test (MAT1), linear relation achievement test (MAT2) and graph of linear equation achievement test (MAT3). The quantitative analysis was conducted by using analysis of covariance (ANCOVA). The results revealed that teaching Cartesian coordinate system and linear relation by using Dynamic Mathematics Software had no significant effect on seventh grade students' achievement compared to the regular instruction. On the other hand, the results also indicated that teaching graph of linear equations by using Dynamic Mathematics Software had a significant effect on seventh grade students' achievement positively.

Keywords: Mathematics Education, Dynamic Mathematics Software, GeoGebra, linear equations.

ÖZ

DİNAMİK MATEMATİK PROGRAMI İLE DOĞRU DENKLEMLERİ KONUSUNUN ÖĞRETİMİNİN YEDİNCİ SINIF ÖĞRENCİLERİNİN BAŞARILARINA ETKİLERİ

Doktoroğlu, Rezzan

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Tez Yöneticisi: Doç. Dr. Erdinç Çakıroğlu

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Bu çalışma, doğrusal denklemler konusunun öğretiminde Dinamik Matematik Programı (GeoGebra) kullanımının, alışılmış matematik öğretimi ile karşılaştırıldığında, yedinci sınıf öğrencilerinin başarılarına etkisini araştırmayı amaçlamıştır. Çalışmada yarı deneysel desen kullanılmıştır. Ankara ilinin Yenimahalle ilçesinde bulunan bir devlet okulundaki 60 yedinci sınıf öğrencisi (32 kız, 28 erkek) çalışmaya katılmıştır. Çalışma 2011- 2012 sonbahar dönemi gerçekleştirilmiş, 3 haftada 9 ders saati sürmüştür. Veriler, 3 matematik başarı testi ile toplanmıştır: Kartezyen koordinat sistemi başarı testi (MAT1), doğrusal ilişkiler başarı testi (MAT2) ve doğru denklemleri grafikleri başarı testi (MAT3). Niceliksel veriler, kovaryans analizi (ANCOVA) ile incelenmiştir. Analiz sonuçları, Kartezyen koordinat sistemi ve doğrusal ilişkiler konularının dinamik matematik programı ile öğretiminin, alışılmış öğretim yöntemi ile karşılaştırıldığında, öğrencilerin başarılarına önemli bir etki etmediğini ortaya çıkarmıştır. Ek olarak, analiz sonuçları, doğru denklemi grafikleri konusunun dinamik geometri programı ile öğretiminin, öğrencilerin başarılarına pozitif yönde bir etki sağladığını ortaya koymuştur.

Anahtar Kelimeler: Matematik Eğitimi, Dinamik Matematik Programı, GeoGebra, doğrusal denklemler.

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LIST OF ABBREVIATIONS

DGS	Dynamic Geometry Software
CAS	Computer Algebra System
RD	Readiness Test
MATs	Mathematic Achievement Tests
MAT1	Mathematic Achievement Test 1 (Cartesian Coordinate System)
MAT2	Mathematic Achievement Test 2 (Linear Relations)
MAT3	Mathematic Achievement Test 3 (Graph of Linear Equations)

CHAPTER 1

INTRODUCTION

Technology is becoming a part of almost all areas of our lives. Recent information technologies are being integrated into learning environments as well. In Turkey, Ministry of National Education has started projects aiming at enhancing the use of computers in schools (Fatih Project, 2012). Numbers of computers in schools have been increased and internet is accessible in almost all schools. Previous studies have shown that teachers have positive attitudes toward using technology in education (Akkoyunlu, 2002; Cüre & Özdener, 2008; Çağıltay, Çakıroğlu, Çağıltay& Çakıroğlu, 2001; Çelik & Bindak, 2005; Göktaş, Yıldırım &Yıldırım, 2008). Since there is such a significant effort and acceptance about information technologies in educational environments, there is a need to determine which way of using technology is more beneficial for learning mathematics comprehensively.

Computers provide extensive opportunities for supporting the learning of mathematics in schools. There are many types of computer applications in mathematics education. Web based interactive learning objects, spreadsheets and graphing programs are some of these tools. In addition to these tools, there are two different types of systems that can effectively support teaching and learning of mathematics in schools. These are *computer algebra systems* and *dynamic geometry systems*. *Computer algebra system* operates on the symbols which are used to represent the abstract mathematical concepts such as integers, rational numbers, complex numbers, polynomials, functions and equation systems (Davenport, Siret & Tournier, 1993). *Computer algebra systems* (e.g. Derive, Mathematica, Livemath) enable students to improve computational skills, to discover, visualize and practice mathematical concepts, and they help the teachers to prepare teaching materials, improve the communication between students and teacher, support the distance education (Majewski, 1999).

On the other hand, *dynamic geometry system* focuses on the relations among points, lines, angles, polygons, circles and other geometric concepts (Sangwin, 2007). Dynamic geometry software simulate straightedge and compass constructions in Euclidean geometry. In addition, geometric relation underlying a construction is preserved when a part of a construction is moved. Students can drag the constructions, change their sizes or directions, and translate or rotate without changing the axiom or theorem behind them. Moreover, measure of an angle, length of a segment, and area of a polygon can be calculated automatically.

GeoGebra, created by Markus Hohenwarter in 2001, is a *dynamic mathematics software* which is combination of *computer algebra system* and *dynamic geometry system.* Related literatures showed GeoGebra's positive effects on students' performance in geometry concepts (Bilgici & Selçik, 2011; Doğan & İçel,2011). In addition, since the combination of visual capabilities of computer algebra system and dynamic changeability of dynamic geometry system enables GeoGebra to examine multiple representation of an equation (Hohenwarter & Fuchs, 2004), GeoGebra was found as an effective tool while teaching algebra (Dikovic, 2009; Kutluca & Birgin, 2007; Zulnaidi & Zakaria, 2012). Confrey and Smith (1991) define representation as a tool for representing mathematical ideas such as graphs, equations and tables. Representation is divided into two categories as *internal* and *external* representation. *Internal representation* is related with the mental models, schemas, concepts, conceptions, and mental objects which cannot be observed directly; but *external representation* is related with concretization of ideas and concepts (Janvier, Girardon, & Morand, 1993, p. 81). Multiple representation is defined as providing the same information in more than one form of external mathematical representation (Goldin & Shteingold, 2001).

There are five representations for an equation which are daily life situation, concrete model, table, symbol, and graph. GeoGebra enable examining three main representations; namely, symbolic, tabular and graphical. Correspondingly with these representations, there are three views on GeoGebra; algebra view, spreadsheet view and graphic view. In algebra view of GeoGebra, symbolic representations of constructions can be observed. Changes on these representations can be observed in the graphic view during the manipulations or vice versa (Figure 1). When user draw a vector, line, or circle, symbolic representations of the input can be simultaneously seen on the screen. The functions can be plot by just writing the equation on the algebra view. Furthermore, spreadsheet view provides with the opportunity to enter not only numerical data but also all types of mathematical concepts such as coordinate of points, equation or any command. Any data entered in spreadsheet can also be seen in graphic view immediately.

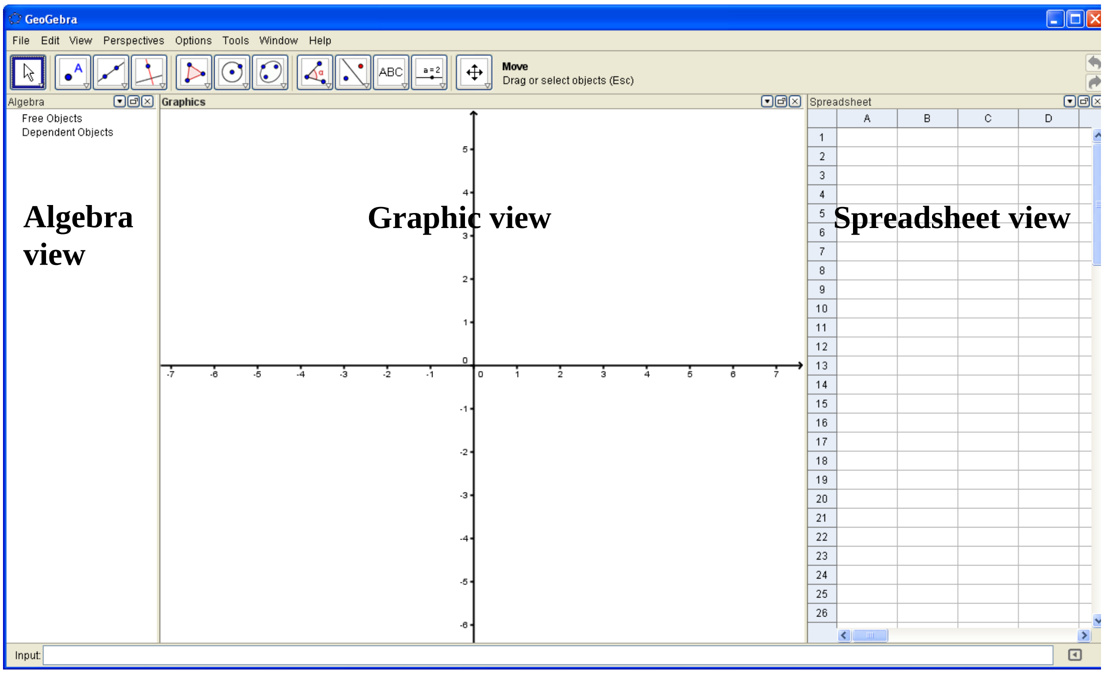

Figure 1 A view of GeoGebra 4.0 screen

In a typical computer algebra system, when the graph of an equation is drawn, no change on the graphic representation of an equation can be done and it is hard to notice the relation between the graph of the equation and its algebraic and tabular representations. However, GeoGebra allows manipulations on each representation of an equation. For example, when user changes parametric values of symbolic representation of an equation, the changes on the tabular and graphical representations can be observed simultaneously. In this way, the relation between the representations can be analyzed.

Another property of GeoGebra is that it is free and multi-platform dynamic mathematics software for all levels of education that combines geometry and algebra in one easy-to-use package. It is an open source software, which allows an increased accessibility for even economically challenged schools. In addition, it allows for usage in various languages including Turkish. All of these properties of GeoGebra make students to examine the relation between representations to understand algebra better.

The importance of multiple representation for understanding algebra comprehensively is stressed in many studies (Keller & Hirsch, 1998; Akkuş, 2004, Özgün-Koca, 2004). According to Ainsworth (1999), multiple representations support developing different ideas and processes, constrain interpretations, and promote deeper understanding. Janvier (1987) defines translation as a process of mapping mathematical representations of one to another. In addition, translating a representation of a concept to another one is necessary to understand the concept entirely (Lesh, Post, &Behr, 1987). Swec (1995) describe graphs as best summary of a functional relation. However, many students consider the graphs as a picture not a representation of a functional relation between two variables (Lapp, 1999). Sfard (1992) indicated that secondary school students were not capable of links between the algebraic and graphical representations of functions. In addition, Sert (2007) found that eighth grade Turkish students' skills in translations among verbal, symbolic and graphical representation of algebra were very limited.

In the national mathematics curriculum, in Turkey, graphic representations of linear equations are covered in seventh grade. Therefore, it is expected that deficiencies and difficulties on learning graph of linear equations at seventh grade level will be barrier to learn some higher level subjects like functions. Therefore it is important to teach graph of linear equation accurately in seventh grade level.

Taking into account all of these, the aim of this research is to investigate the effects of teaching linear equations with dynamic mathematics software on seventh grade students' achievement.

1.1 Research Questions and Hypotheses

1.1.1 Research Questions

The study addresses the following research questions:

P1. What are the effects of dynamic mathematics-based instruction as compared to regular instruction on seventh grade students' achievement on Cartesian coordinate system?

P2. What are the effects of dynamic mathematics-based instruction as compared to regular instruction on seventh grade students' achievement on linear relations?

P3. What are the effects of dynamic mathematics-based instruction as compared to regular instruction on seventh grade students' achievement on graph of linear equations?

1.1.2 Null Hypotheses

The following null hypotheses were investigated based on the research questions.

Null Hypothesis 1: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on Cartesian coordinate system after controlling their readiness test scores.

Null Hypothesis 2: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on linear relations after controlling their readiness test scores.

Null Hypothesis 3: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on graph of linear equations after controlling their readiness test scores.

1.2 Significance of the Study

Information technologies will continue to improve and will potentially become an important part of 21st century classrooms. However, the effective way of using information technologies must be found in learning environments, otherwise just bringing technology in the class is not enough. There is a need to understand how technology should be integrated learning environment. This study provides some insight into how technology-based instruction influence 7^{th} grade students' achievement in mathematics.

The importance of multiple representations and the relation between representations in linear equation to comprehend the subject better is emphased in MoNE (2009). GeoGebra enables students to examine the relation between tabular, symbolic and graphical representation of a linear equation by observing three representations on the same screen. Manipulating one of them and examining the changes on the others are also possible with the software. There is a need to understand how dynamic mathematics software contributes to teaching/ learning linear equations. This study sheds light on understanding of the contribution of dynamic mathematics software on teaching and learning linear equations.

According to Çakıroğlu, Güven and Akkan (2008), mathematics teachers evaluated themselves as incapable of designing, conducting and evaluating a technology supported environment. To conduct this study, appropriate lesson plans whose topics focusing on Cartesian coordinate systems, linear relations and graph of linear equation were developed to be used with GeoGebra. These lesson plans might be considered as examples for the teachers who have concerns about technology usage in classroom. It is possible to understand how these lesson plans improve students' achievement on graph of linear equation through this study, which does not only contribute to the mathematics education literature but also provides teaching implications for teachers, curriculum developers, and educational policy makers.

1.3 Definition of the Important Terms

Dynamic Mathematics Software: It is a computer software which is combination of dynamic geometry and computer algebra systems. Dynamic geometry system allows creating and then manipulating constructions. The software maintains all relationships that were specified as essential constraints of the original construction (Lehrer&Chazan, 1998). Computer algebra systems symbolically perform algebra analytic geometry and calculus. They use equations to determine their relative positions to each other and show their graphical representations (Prenier, 2008)**.** In this study, GeoGebra was used to teach Cartesian coordinate system, linear relation and graph of linear. It is as easy as a dynamic geometry software but also provides some basic features of Computer Algebra Systems to bridge some gaps between geometry, algebra and calculus (Hohenwarter, Preiner& Yi, 2007). Since GeoGebra has the feature of showing tabular, symbolic and graphical representations of an equation at one screen and enable manipulation between the representations, this study was based on the use of GeoGebra.

Regular instruction: Regular instruction is based on textbook approach. The activities on the related topics are applied respectively. In this study, the instructor taught the topics with regular instruction to control group students.

Dynamic Mathematics-Based Instruction: Dynamic Mathematics-Based Instruction is based on the delivery of the activities and tasks with an integration of dynamic mathematics software. In this study, the same activities which were based on textbook were taught to experimental group students by the help of dynamic mathematics software.

Multiple representations: Multiple representation is defined as providing the same information in more than one form of external mathematical representation (Goldin & Shteingold, 2001). In this study, multiple representations of a linear equation, which are tabular, symbolic and graphical, were used to comprehend the concept.

CHAPTER 2

LITERATURE REVIEW

The purpose of this study was to investigate the effects of using Dynamic Mathematics Software (GeoGebra) on seventh grade students' achievement in linear equations. In this chapter, the review of literature related with this study is explained into four sections. The first section reviews the literature about multiple representation. The second section focused on literature on research on multiple representation. The third section emphases the literature on technological tools in algebra teaching. A coherent summary of the literature review is drawn in the fourth section.

2.1 Multiple Representation

A number of theories on multiple representation was placed on mathematics education literature. One of them was Dienes' Multiple Embodiment Principle as stated by Lesh, Post and Behr (1987). The principle focused on the idea that physical representations provide students' understanding of mathematical concepts. Diene defined multiple representation as an aid in students' mathematical understanding (as cited in Lesh, Post and Behr, 1987).

The main model that guided this study was drawn from Janvier's Representational Translations Model (1987). The model proposed three stages of mathematical understanding: using different representations, artful management within representations and translation from one representation to another. The four representations of Janvier's model were verbal descriptions, tables, graphics and formula. Janvier described direct translation as translation among two representations and indirect translation as translation among two representations by using other representations.

2.2 Research on Multiple Representation

Effective algebra teaching was associated with its multiple representations which are tabular, symbolic and graphic (MoNE, 2009). Multiple representation was investigated from different point of views. Rider (2004) investigated the probable advantages of a multi-representational curriculum on students' understanding of and transitions among graphical, tabular, and symbolic representations of algebraic concepts. In the study, eight students were taught with traditional algebra curriculum which emphasized symbolic representation. The other eight students were taught with reform-based algebra curriculum in which representations were introduced simultaneously without any priority. Interviews were done with these students. The results revealed that multi-representational curriculum could be effective for helping students to improve their conceptual knowledge of algebraic and functional concepts.

Brenner, Brar, Duran, Mayer, Moseley, Smith and Webb (2005) aimed to re-design a pre-algebra unit to put emphasis on problem translation skills. Seventh and eighth grade students from seven pre-algebra classes participated in the study. Four of these classes focused on problem representation skills. On the other hand, three of them participated in traditional instruction as comparison groups. Students who participated in representation-based units represented mathematical relationships with tables, graphs, pictures, and diagrams. Pre-test and post-test on symbol manipulation tasks, such as solving equations; and problem representation tasks, such as translating word problems into equations, tables, and graphs were administered to the students. The authors concluded that an appropriate instruction could be helpful for the learning of representational skills. The students who participated in representation-based unit used appropriate tables, diagrams, equations whereas comparison group students failed to use relationships among representations. Researchers concluded that a unit could be redesigned so as to emphasize representational skills.

Beyranevand (2010) investigated the associations between students' achievement levels and two abilities regarding multiple representations and linear relationships.

The two abilities were to recognize the same linear relationship represented in different ways to solve linear equations with one unknown presented multiple ways. The author also investigated students' preference toward particular representations. 443 seventh and eighth grade students participated in the study. Data was collected by an instrument including a survey and problem sets. Survey consisted of likert scale questions on attitudes toward different representations, and it was asked to the students to solve problems presented in verbal, pictorial and symbolic modalities. According to the responses, interviews were also made. Multiple regression/correlation and chi-square analyses were used to compare students' answers. The results revealed that students who managed to identify the same linear relationship with one unknown problem presented in different ways and solve linear equations with one unknown presented multiple ways were significantly more likely to perform a higher level. In addition, the results of this study revealed that low-achieving students were more likely to prefer using pictorial representations while high-achieving students prefer using verbal and symbolic representations when solving linear equations.

In Turkey, Akkuş (2004) investigated the effects of multiple representations-based instruction on seventh grade students' algebra performance, attitudes toward mathematics, and representation preference. 131 seventh grade students from two public schools participated in the study. Algebra achievement test, translations among representations skill test, and Chelsea diagnostic algebra test were used to assess students' algebra performance. Moreover, mathematics attitude scale was used to assess students' attitudes toward mathematics. Representation preference inventory was also administered before and after treatment to determine students' representation preferences. At the end of the treatment, interviews were made with students from both groups for obtaining qualitative data. Multivariate covariance and chi square analyses' results showed that multiple representations-based instruction had a significant effect on students' algebra performance compared to the conventional teaching. In addition, no significant difference between groups was found in terms of attitudes towards mathematics. Qualitative data analysis revealed that experimental group students used variety of representations for algebra problems and were capable of using the most appropriate one for the given algebra problems.

Sert (2007) investigated eighth grade students’ skills of translating among different representations; graphic, table, equation, and verbal sentence of algebraic concepts and their most common errors in making these translations. 705 eighth grade students from 103 schools were participated in the study. Translation among different representations of algebraic concepts test developed by the researcher was administered to the students. The results revealed that eight grade students had poor skill in translating the representations. It was detected that the most problematic translations were from tabular, graphical and symbolic to verbal statement. Translations from verbal statement, graphical and symbolic to tabular were detected as the easiest.

2.3 Research on Technological Tools in Algebra Instruction

The effectiveness of some technological tools which enable to link multiple representations of equations such as Function Probe, Math Trax, TI-83 graphic calculator was examined for high school and middle school students in many studies. For example, Borba & Confrey (1996) investigated a 16-year-old student’s constructions of transformation of function by using Function Probe. In that study, relation between graphs and tabular values and also relation between graph and algebraic representation were examined. The results pointed that visual reasoning is a powerful form of cognition. Moreover, multiple representations increased the student’s motivation to complete the given investigation.

In a similar way, Özgün- Koca (1998) investigated the remedial freshmen students' attitudes towards to multiple representations, students' choice of representation when solving a problem, and the effects of computer settings on students' choices of representation. A four-part activity was implemented. In the first part, no suggestion was given to students. They were free to choose any representation. In the second, third, and final parts, students examined the problem in graphical, tabular and algebraic representation respectively. She observed students’ usage of software, and administered a questionnaire to obtain students' attitudes towards multiple representations and mathematics. The results indicated that, the attitude towards mathematics were still negative. The researchers claimed that the reason for this was due to the fact that the students were remedial students. Moreover it was found that students' previous knowledge, experiences and personal preferences influenced their choices of representations. She suggested that instructors should prepare a multi-representational environment. In this way students could experience different representations and select the most appropriate one needed for a problem.

Özgün-Koca (2004) also investigated the effects of multiple linked representations on ninth grade students' learning of linear relationships. In this experimental study, three groups were compared with respect to the usage of different teaching methods. One group used a linked representation software; Videopoint, the second group used the same software but with semi-linked representations, and the third group was the control group. Linked multiple representations allowed to see the changes on one of the representation on the other representations automatically. Semi-linked representations were defined as the changes within one of the representation are available only upon request but not automatic. The results indicated that linked representation had a positive effect on ninth grade students' achievement and also semi-linked representations could be as effective as linked representations.

Pilipezuk (2006) investigated the effects of graphing technology on pre-algebra students' understanding of function concept. Five different types of function, namely polynomial, rational, exponential, logarithmic, and trigonometric were measured according to three components as modeling, graphing and problem solving. In this quasi-experimental design, experimental group students participated in five Calculator-Based Laboratory activities whereas the control group students' did not engage in any of these activities. The data collected from pre and post test results were evaluated by both quantitative and qualitative methods. Multivariate and univariate analyses results indicated that there were no significant differences between groups on three main components that were modeling, graphing and problem solving. On the other hand, qualitative analyses results showed that experimental group students outperformed control group students on graphing a function. In addition, the results revealed that experimental students were more successful on scaling and demonstration of the local and end behavior of a function. Moreover, graphical methods were used more often by the experimental group students to solve problems. Lastly, according to descriptive statistics, control group students could not give correct answer to the questions related sketching graph as twice as the number of the questions which were not answered by the experimental class. Overall, Pilipcezuk (2006) suggested that Calculator-Based Laboratory activities can affect the students' performance positively. Moreover it was indicated that this positive effect of graphic calculator can be attributed to its ability of showing multi-representation of a function which are graphical and tabular to explore and analyze function.

Tajuddin, Tarmizi, Konting and Ali (2009) examined the effects of using graphic calculators on high school students' performance on Straight Line topic on the Malaysian mathematics curriculum and also their meta-cognition awareness level. Straight line topic included the concept of the gradient of a straight line, the concept of the equation of a straight line, the concept of the gradient of the straight line in Cartesian Coordinates, the concept of intercept, and the concept of parallel lines. In this quasi-experimental design study, experimental group students were taught the topic with using TI-83 graphic calculator while control group students were taught the same topic conventionally. Straight Lines Achievement Test, Paas Mental Effort Rating Scale and Meta-cognitive Awareness Survey were administered to students and the independent t-test results indicated that there was a significant difference between groups in the favor of the experimental group. In other words, using graphic calculator improved high school students' performance on the concept of straight line and their level of meta-cognitive awareness.

Kabaca, Çontay and İymen (2011) purposed to construct the concept of parabola with the relationship between its algebraic and geometric representation by using GeoGebra. A learning environment supported by GeoGebra including 4 phases was prepared and the lesson was implemented in one class hour. GeoGebra was used as a presentation tool and students examined the algebraic and geometric representation of a parabola in the fourth phase. The 11^{th} grade level class including 23 students was videotaped during this hour. The students' important reactions were reported and interpreted. As a result, the 4 phases learning environment supported by GeoGebra was found practical and beneficial in terms of examining some advanced properties of a parabola.

Kutluca and Birgin (2007) used GeoGebra in their case study to evaluate high school students' views about learning mathematics with GeoGebra. 23 students learned quadratic functions with GeoGebra. At the end of the study, evaluation form including seven open ended questions which was prepared by the researcher was administered. According to the results, it was concluded that learning with GeoGebra provided better learning and it was found as fun and interesting by the students.

Another research study involving the use of GeoGebra was conducted by Zulnaidi and Zakaria (2012). They examined the effects of GeoGebra use on students' conceptual and procedural knowledge of function. 124 high school students participated in the study. The study used quasi-experimental non-equivalent pretest-posttest control group design. The results revealed a significant difference between groups. It was concluded that GeoGebra improved high school students' not only conceptual knowledge but also procedural knowledge. In addition, it was claimed that GeoGebra helped students to understand the relation between conceptual and procedural knowledge.

Apart from the studies conducted with high school students, Hines (2002) studied with middle school students. Hines (2002) examined an eighth grade student's interpretation of linear equations while he was creating in dynamic physical model using a spool elevating system, and an Etch-a-Sketch^{TM} toy. Throughout the study, the student used different representations as tables, equations and graphs to represent functions. The data collection instruments were algebra, geometry and proportional reasoning tests of the Chelsea diagnostic tests. At the beginning of the study, the questions prepared by the researcher were asked and the student was expected to explain the problem in his own words, by making a table, creating an equation, and creating graphs. But it was seen that he was not able to make interpretations about the equations and graphs as representations for functions. During the interview the participant dealt with dynamic physical models in order to gain an understanding of linear functions. At the end of the study, the participant was reported to develop understanding of linear function by the help of the dynamic physical model.

Another research conducted with middle school students was done by Işıksal and Aşkar in 2005. The effects of spreadsheet and dynamic geometry software, Autograph, on the achievement and self-efficacy of seventh grade students were investigated in this study. Three instructional methods which were spreadsheet-based instruction, Autograph-based instruction and traditionally based instruction were randomly assigned to three classes. Activity sheets including same questions but different directions with respect to the instruction method were prepared. The content of the questions included equations, symmetry, coordinate plane, graphs of linear equations and solving systems of linear equations by graphing method. Students in the spreadsheet-based and autograph-based instruction classes worked on the questions using spreadsheet and autograph individually without any guidance. Traditional-based instruction group students also worked on the same questions but they did not use any technological device. Mathematics achievement test, Mathematics self-efficacy scale and computer self-efficacy scale were administered both before and after the treatments. According to analysis of covariance results of mathematics achievement test, the autograph group students and traditional group students were performed better than the spreadsheet group students. In addition, no significant difference was found between autograph and traditional group students' test scores. Moreover, autograph students' mathematics self-efficacy test scores were significantly greater than scores of traditional group students and also there was no significant difference between autograph and excel group students' scores, and between excel and traditional group students' scores. Besides, a significant correlation was found between self-efficacy scores and mathematics achievement scores.

Önür (2008) investigated the effects of graphic calculators on eighth grade students' achievement in graph of linear equations and the concept of slope. In quasi-experimental research design, two classes were randomly assigned as experimental and control group. 27 students in experimental group learned graph of linear equations and concept of slope with using graphic calculator while 27 students in control group learned the same topics without using graphic calculator. An achievement test was applied before and after the treatment and six experimental group students were interviewed. The results indicated that graphic calculator had a significant effect on eighth grade students' achievement in graph of linear equation and slope concept. In addition, gender did not affect students' achievement significantly. Moreover, according to interview results, using graphic calculator affected students' attitudes toward mathematics positively.

Similarly, Birgin, Kutluca and Gürbüz (2008) investigated the effects of computer assisted instruction on seventh grade students' achievement in coordinate plane and graph of linear equations. In the pre-test post-test quasi-experimental design, experimental group learned the topics with spreadsheet and Coypu software whereas the control group learned the same topic traditionally. The computer assisted instruction materials developed by Kutluca and Birgin (2007) with using spreadsheet and Coypu software were used in the experimental group. A mathematics achievement test was administered before and after the treatment. Independent sample t-test analysis results showed that experimental group students' success was significantly higher than the success of the control group students.

Apart from analyzing effectiveness of technological tool in algebra achievement, Nguyen (2011) used Math Trax graphing program to discover the effects of it on eighth grade students' learning attitudes, and students' individual explorations through collaborative learning with peers. The students had a chance to learn how a graphic program used for graphing linear functions which was already learned. The experiment was carried out with 20 students throughout the school year. Two equal sized groups were formed as Math Trax individual group and Math Trax collaborative group. The differences of the Math Trax graphic program than the other program were related to having both audio and visual features. These features were used during the treatments. The students firstly heard the algebraic form of a linear equation and then tried to guess its graphic view and finally checked their answers by using the program. According to discussions, questions, and reflections of the students at the end of the study, it was revealed that using math Trax program increased the students' attitudes and Math Trax Collaborative group students were better at making explorations and prospective in open discovery.

2.4 Summary of Literature

The foci of reviewed studies on multiple representations were the benefits of using multiple representations and translating among these representations. All studies reported here were conducted with middle school students. A variety of data collection tools and data analysis were used in these studies. The results of these studies demonstrated that using multiple representations and translating among these representations improved the conceptual understanding and achievement level of students in the domain of algebra. Furthermore, multiple representation-based instructional designs could help students improve their skills regarding using multiple representations and translating among them.

The effectiveness of using technological tools in mathematics classrooms was demonstrated in many experimental studies. Technological tools such as Function Probe, Videopoint, TI-83 plus graphic calculator and also GeoGebra were used in these studies conducted with both high school and college level students.

The studies conducted with high school students focused mostly on multiple representations of functions such as algebraic, graphical and tabular. In all studies, the importance of making transitions between these representations was seen as a core skill for the comprehension of the concept. Also these experimental studies examined whether conducting mathematics lessons with the help of technological devices such as graphical calculators and some computer software such as Function Probe. Most of the studies showed evidences of positive effects of using these tools and software on both students' achievement in function concept and attitudes towards mathematics lessons. As most related to this study, the studies examining the effects of using GeoGebra for the function concept, the software was found to be practical and beneficial.

Several studies reviewed in this chapter focused on the effects of technological tools, such as graphing calculators, and computer software, such as spreadsheet and autograph, on middle school students' understanding of the concept of linear equations and also self-efficacy. Most of the studies had again evidences of positive effects of such tools and software on students' achievement in the concepts of linear equations, slope and Cartesian coordinate system. The results of these studies also demonstrated the positive effect on students' attitudes towards mathematics lessons.

Apart from those studies, a limited number of studies investigated the effects of using GeoGebra software on students' achievement and attitudes. Yet, the common point of those studies was related to the effectiveness of GeoGebra software for the concept of linear equations, Cartesian coordinate system and slope. However, literature on dynamic mathematics software usage at middle school level for the teaching and learning of linear equations is still limited. Therefore, there is a need to investigate the effectiveness of using GeoGebra on students' achievement in linear equation at middle school level. Besides, in this study students were able to examine all representations simultaneously on the same screen of Dynamic Mathematics Software for making translations. For this reason, this study differs from other studies concerning multiple representations.

CHAPTER 3

METHODOLOGY

In this chapter, research design, the participants, instruments, procedure and data analysis of the study are presented.

3.1 Research Design

The purpose of this study was to investigate the effects of teaching Cartesian coordinate system, linear relations and graph of linear equations with dynamic mathematics software, GeoGebra, on students' achievement. Since, according to Fraenkel and Wallen (2006), experimental research is the best way to establish cause and effect relationship, *randomized posttest only control group design* was used to discover the effect of the learning with dynamic mathematics software on success. 60 seventh grade students of the school were randomly assigned to the experimental and control groups equally. Then, 30 students in the experimental group received an instruction by using GeoGebra in the computer laboratory and 30 students in the control group attended to a regular instruction in a classroom setting during three weeks. After the treatment, three mathematics achievement tests were administered to both groups. The figure of this design is as follows.

60 students	Random Assignment of 30 students to experimental group	RT	Treatment with using GeoGebra	MAT1 MAT2 MAT3
	Random Assignment of 30 students to control group	RT	Treatment with regular instruction	MAT1 MAT2 MAT3

Figure 2 Randomized Posttest Only Control Group Design

3.2 Participants

To determine the participants of the study, a convenient sampling method was utilized. 60 seventh grade students of the public school, in which the researcher had been working, in Yenimahalle district in Ankara participated to the study. The school was also chosen due to its suitable technological infrastructure. The school had a computer and a projector in each classroom. In addition, there was a computer laboratory which had 22 computers, a projector and a smart board. These technological devices were needed during the study.

The number of girls and boys were 32 and 28 respectively. In the experimental group, there were 15 girls and 15 boys, and in the control group, there were 17 girls and 13 boys. The school was inside the district of the staff houses of the police, postal services and the bank of provinces, and so, all students' parents were civil servants in these public institutions. Therefore, socioeconomic levels of students were similar and all of them had a computer in their houses. Also the computer laboratory could be used for students' independent studies from after the school hours to 17:00. It could be assumed that all seventh grade students of the school had a minimum required knowledge of computer use, which they used during the treatment.

3.3 Measuring Instruments

For this study, four instruments were used to collect data. Readiness test was administered in order to examine the entry levels of experimental and control group students in terms of their mathematics achievement at the beginning of the study. Three Mathematics Achievement Tests; Cartesian coordinate system achievement test, linear relation achievement test, and graph of linear equation achievement test were administered to measure the students' success after the treatment.

3.3.1 Readiness Test

A readiness test was developed to check the students' mathematics achievement levels before the treatment. The results gave information about the equal success of experimental and control group students.

In the readiness test, there were 15 multiple choice items. Nine of these items were adopted from previous years' high school entrance examination (SBS). The rest of the items were developed by the researcher. The content of the test included rational numbers, integers, patterns, equations and linear relation which were covered from beginning of the semester until the time of the treatment as seen on Table 1.

Table 1 Specification Table for Readiness Test

Content of the Readiness Test	Objectives	Question number
Rational Numbers	Find the rational number which correspond to a point on the numerical axis	Q1
	Solve rational number questions needed more than one operations	Q2
	Solve rational number problems	Q7, Q8
Integers	Guess the integers on an operation	Q3
	Find the integer corresponding to a point on the numerical axis	Q4
	Find the false step of an operation on integers	Q6
	Show mathematical representation of operational models of integers	Q10
	Solve multiple operations on integers	Q11
Pattern	Find pattern when a number belong to it is given	Q5
	Find the pattern on a geometric figure	Q9
Equations	Solve one unknown equation	Q12
	Solve two unknown equation while one unknown of it is given	Q13
Linear relations	Transform representation of a relation from graphical to table representation.	Q14
	Transform representation of a relation from table to symbolic representation	Q15

Five experienced teachers' opinions as experts were taken. The items were checked in terms of content coverage, language use in the test, clarity of items and difficulty level. They agreed on appropriateness of the test.

Readiness test was implemented to both experimental and control groups. The correct answers and the wrong answers were evaluated as 1 points and 0 points respectively. Maximum achievable points for the test were 15 points. Minimum possible points were 0 points. According to result, Cronbach's alpha, which shows the reliability of the test, was calculated as .71.

3.3.2 Mathematics Achievement Tests (MATs)

Three Mathematics achievement tests were developed by the researcher to assess students' understanding of the topics; Cartesian coordinate system (MAT1), linear relation (MAT2), and graph of linear equation (MAT3). After the treatments, mathematics achievement tests were administered to both experimental and control groups.

The questions were prepared according to the mathematics textbook, student workbook and previous years' high school placement exam (SBS). The objectives were specified by the researcher in terms of student learning at the end of each class hour. These objectives are clearly shown in the specification tables below.

Table 2 Table of Specification for Mathematics Achievement Test 1

OBJECTIVES		QUESTIONS
Cartesian Coordinate System	Give examples about daily life usage of “ordered pair”	Q1
	Explain the elements of Cartesian coordinate systems which are ordinate, abscissa, origin and region.	Q2
	Find points on the Cartesian coordinate system.	Q2, Q3, Q5
	Estimate the coordinates of the point which is a part of a shape.	Q4, Q5

Table 3 Table of Specification for Mathematics Achievement Test 2

OBJECTIVES		NUMBER OF QUESTION
Linear Relationship	Transform representation of a linear relation from tabular to symbolic representation	Q2
	Compare linear and nonlinear relations according to their symbolic representations	Q4
	Compare linear and nonlinear relations according to their graphical representations	Q1
	Transform representation of a linear relation from tabular to graphical representation	Q5
	Transform representation of a linear relation from graphical to tabular representation	Q3

Table 4 Table of Specification for Mathematics Achievement Test 3

OBJECTIVES		NUMBER OF QUESTION
Graph of linear equation	Explain the symbolic representation of a linear equation passing through the origin.	Q2
	Transform representation of a linear equation from tabular to graphical representation	Q1
	Transform representation of a linear equation from symbolic to graphical representation	Q5
	Find points on the graph of a linear equation	Q3
	Find the points which intercept the axes	Q4

In calculating the scores obtained in each test, the correct answers and the wrong answers were evaluated as 1 points and 0 points respectively. All of the items in MAT1 were multiple choice types. MAT2 had 3 multiple choice, 1 table completion and 1 open-ended item. MAT3 had 4 multiple choice questions and 1 graphing question. The correct answers were evaluated as 1 point for multiple choice questions. The objective of the graphing question was transforming representation of an equation from symbolic to graphical. To solve this question there was a need to find two points and then connect them on Cartesian coordinate system. This item was scored in a way that finding each point correctly as 1 point and drawing graph correctly as 1 point, totally 3 points. The mean of these three scores were used as the graphing item's score. Maximum achievable score for MAT1, MAT2 and MAT3 were 5 points. Minimum possible score was 0 points.

Since eighth grade students had learnt the covered topics in previous year, a pilot administration of the achievement test was applied to 63 eighth grade students for statistical item analysis. Item analysis software, ITEMAN, was used for the analysis. Cronbach's alpha coefficients, which show internal consistency reliability for the tests, were calculated for MAT1 as 0.71, for MAT2 as 0.67 and MAT3 as 0.66. According to Haladyna (1999), values between .60 and 1.00 are in acceptable range. The intervals of item discrimination and item difficulty values for each question are represented in Table 5 and Table 6.

Table 5 ITEMAN results

Item Discrimination Intervals	Test Items
0.31 – 0.40	MAT1-Q5, MAT3-Q3, MAT3-Q4, MAT3-Q5
0.41 – 0.50	MAT1-Q4, MAT2-Q1, MAT2-Q4, MAT3-Q2
0.51 – 0.60	MAT1-Q1, MAT1-Q2, MAT1-Q3, MAT2-Q2, MAT2-Q5, MAT3-Q1
0.61 – 0.70	MAT2-Q3

Table 6 ITEMAN results

Item Difficulty Intervals	Test Items
0.00 – 0.10	
0.11 – 0.20	MAT2-Q2
0.21 – 0.30	MAT3-Q4
0.31 – 0.40	
0.41 – 0.50	MAT2-Q4, MAT2-Q5,
0.51 – 0.60	MAT2-Q3, MAT3-Q3
0.61 – 0.70	MAT1-Q5, MAT3-Q1
0.71 – 0.80	MAT1-Q3, MAT1-Q4
0.81 – 0.90	MAT1-Q1, MAT1-Q2, MAT2-Q1, MAT3-Q2, MAT3-Q5
0.91 – 1.00	

Five experts' opinions, 3 experienced mathematics teachers, 1 mathematics education faculty member, and 1 research assistant in mathematics education, were taken. Experts judged the items in terms of content coverage, language used in the test, clarity of items, and difficulty level measured. According to their judgments and

ITEMAN results 2 items, MAT2-Q2 and MAT3-Q4, were revised because of their high difficulty level and ambiguous format.

The reliability coefficients of MAT1, MAT2 and MAT3, in the actual study, were calculated as .74, .68 and .65 respectively.

3.4 Variables

The variables in this study were categorized as independent, dependent and covariates. The independent variables of the study were the treatments, instruction through dynamic mathematics versus regular instruction (without using any dynamic mathematics software). The dependent variables were students' three mathematics achievement tests scores, namely scores on MAT1, MAT2, and MAT3. Covariates of this study were students' readiness test scores administrated before the treatment.

3.5 Procedure

60 students in three classes of the school were randomly assigned to two groups by using Excel. For this process, Randbetween function of Microsoft Excel was used. Two separate lists were created for male and female students in a new worksheet; for each list, name of the students were numerated for classification. There were 32 female and 28 male students. To divide the female group into two equal and random groups, using Randbetween function random numbers between 1 and 32 were generated, until 16 different numbers have been reached. Same procedure was applied for the male students. Consequently, two groups with 16 females and 14 males were created each. Afterwards the experimental and control groups were selected tossing a coin. A boy from a group and a girl from the other group wanted to change their groups because of their extracurricular activities which coincidence with the treatment time. At the end, the groups were formed with 15 girls and 15 boys for experimental and 17 girls and 13 boys for control group.

The treatment was implemented in three weeks, totally nine class hours for each group in 2011- 2012 fall semester was used. Students in both groups took the treatments after regular school hours. Experimental group took treatment between 14:40 and 16:10 with 10 minutes break on Mondays and between 14:40 and 15:20 on Tuesdays. On the other hand, control group took treatment between 15:30 and 16:10 on Tuesdays and between 14:40 and 16:10 with 10 minutes break on Wednesdays.

Since the treatments were implemented after school hours, the topics could be taught independently from the annual plan suggested by the Ministry of National Education. Readiness test was administered before the treatment at the same time for both groups in their regular classrooms. One day after the last day of the treatment, MATs were implemented. The time schedule is shown in Table 7.

Table 7 Time Schedule

Duration (min.)	Objectives	Activities	Date Covered Experimental / Control
40	Explain and use two dimensional Cartesian coordinate system	-Giving examples about using ordered pairs in daily life -introduction of elements of Cartesian coordinate system(apsis, ordinate, origin, regions)	21.11.2011 21.11.2011
40	Explain and use two dimensional Cartesian coordinate system	-Finding points on Cartesian coordinate system - signs of coordinates of points according to regions	22.11.2011 23.11.2011
40	Explain and use two dimensional Cartesian coordinate system	-practice on finding points on coordinate system (creating a dolphin picture by connecting the points)	22.11.2011 23.11.2011
40	Explain linear equation	-reviewing relation on numerical pattern with examples of linear and nonlinear examples	28.11.2011 28.11.2011
40	Explain linear equation	-using graph to understand linearity	29.11.2011 30.11.2011
40	Explain linear equation	-classifying linear and nonlinear equations -realizing linear equations are in the form of y=ax+b	29.11.2011 30.11.2011
40	Draw graph of linear equations	-creating a table for a giving linear equation - to find value of y, giving any value to x - constant linear equations	05.12.2011 05.12.2011
40	Draw graph of linear equations	-creating a table for a giving linear equation - to find value of x, giving any value to y -findings points which intercepts x and y axes.	06.12.2011 07.12.2011
40	Draw graph of linear equations	-practice on drawing linear graph	06.12.2011 07.12.2011

Computer laboratory of the school was arranged for the experimental group. There were 22 computers. Thus, 8 laptops were added, to make sure that each student is working individually with a computer. On the other hand, a regular classroom of the school was chosen for the control group.

Since the researcher was also the instructor, another teacher, who teach computer technology at the school, took a place in the study as an observer in order to check and confirm that researcher as instructor did not have any bias. She took notes during all class hours for each group.

Lesson plans for each group were prepared based on the textbook. The activities on the textbook were rearranged to integrate GeoGebra for experimental group. Activity sheets included directions about what students do on a GeoGebra file. Students used spreadsheet part of the GeoGebra to make a table, and they used graphic view part of it to draw a function. On the other hand, activity sheets prepared for control group include tables and coordinate plane drawn on them. Same examples and questions were used in both groups to reach the same objectives. The only difference between the activities was the usage of GeoGebra.

The prepared lesson plans were checked by three experienced mathematics teachers to determine whether they were mathematically correct and appropriate for achieving the objectives. According to their comments and recommendations, all lesson plans were revised to obtain a consistency between the objectives and content of the activities.

Students were familiar with the usage of GeoGebra from their regular mathematics classes. Therefore, the researcher did not have to spend extra time to teach GeoGebra.

For ethical reasons, two weeks after this study, the topics were covered again under regular mathematics sessions for the control group students. Students were instructed through GeoGebra in computer laboratory. Therefore, all participants in this study had the opportunity to study in dynamic mathematics software-based learning environment.

3.6 Instruction in Experimental and Control Group

In both groups, there were three main topics, namely Cartesian coordinate plane, linear relations, and graph of linear equations. The instruction for each of these topics will be explained in the following sections.

3.6.1 Cartesian Coordinate Plane

At the beginning, the concept of "ordered pairs" was covered by giving examples of its daily life usage by showing some pictures such as movie theater and mathematical location of Turkey in both groups. Then, experimental group students found points on the Cartesian coordinate plane by using sliders which helped to the students to arrange the abscissa and ordinate of a point. In figure 3 the GeoGebra screen is shown. The arrows clearly show how x and y coordinates of a point changed when moving on the plane.

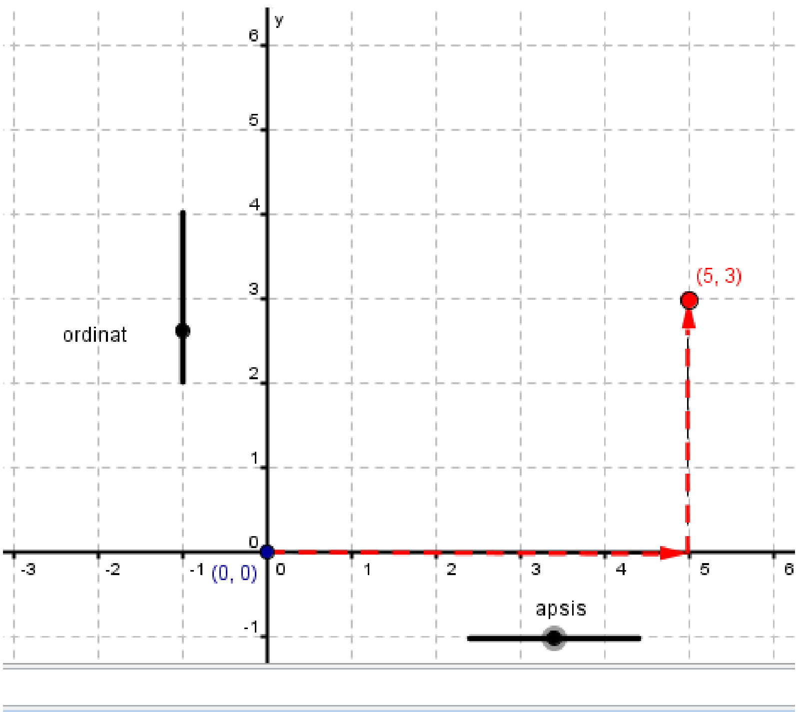

Figure 3 A GeoGebra Activity Related with Finding Coordinates of a Point on a Coordinate Plane

Moreover, students construct some figures such as house, car, or tree by using the input part of the GeoGebra. A point was put on the coordinate plane automatically when its coordinates (e.g. (5,3)) was written on the input box. They tried to find the next point to construct their figure and finally they connected the points with segments. Some examples from these constructions are presented in Figure 4.

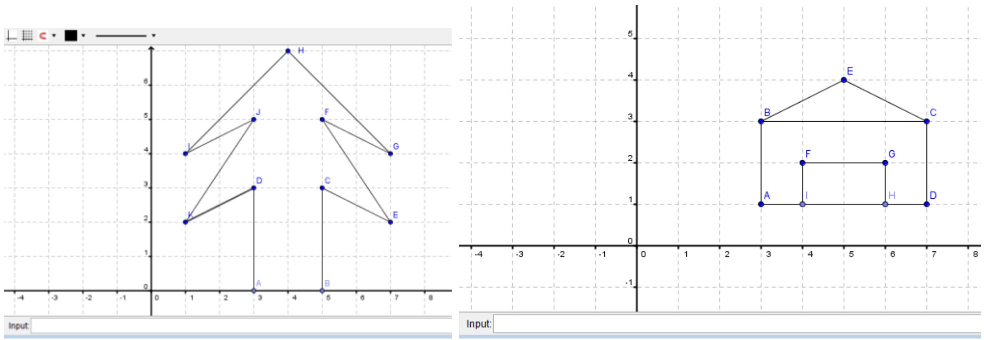

Figure 4 Two Examples of Students' Constructions

On the other hand, in the control group, it was explained that how a point was found on a coordinate plane by the instructor in traditional way. Then, they found the points, on the activity sheet, on the coordinate plane which was already drawn on their sheets. After that, some figures were shown and they were asked to estimate what the missing point was. For example, as seen in Figure 5, students guessed the missing point to form a parallelogram.

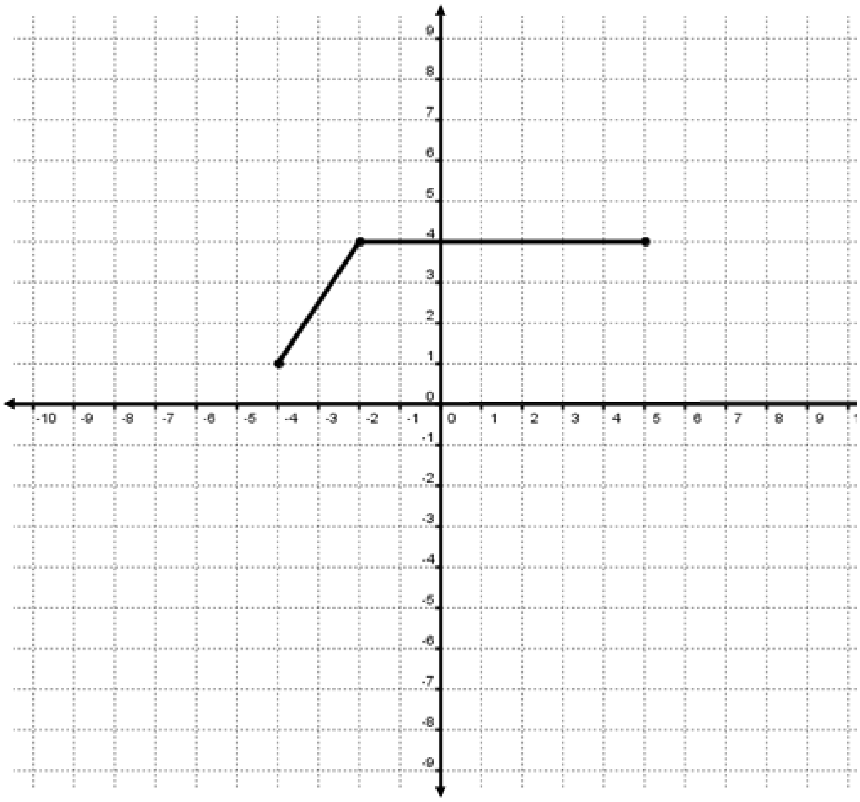

Figure 5 Example on Finding Missing Point of a Shape for Control Group

3.6.2 Linear Relations

The purpose of the activities were to teach the symbolic representation of a linear equation, in the form *y=ax+b*. In addition, the purpose was to emphasize that every relation does not have to be linear. In the activity sheet, there were 4 relations, which represented daily life situation, 3 of them were linear and one of them was not linear. Students observed the graph of these relations and tried to find at under which conditions, a relation was linear.

Experimental group students used spreadsheet part of the GeoGebra to make tables and they used graphic view of it for Cartesian coordinate plane. For example, it was asked on the activity sheet 3 (Appendix B) to check a relation's linearity: if one kilogram apple is two liras, make a table to examine the relation between its price and weight. The ordered pairs of weight and prize were written on the right column of each related row in the spreadsheet. The points which represent these ordered pairs were put on the Cartesian coordinate plane automatically by the software. Then students drew a line to check its linearity. The final views of a student's GeoGebra file for a linear and a nonlinear relation are shown below in Figure 6 and Figure 7.

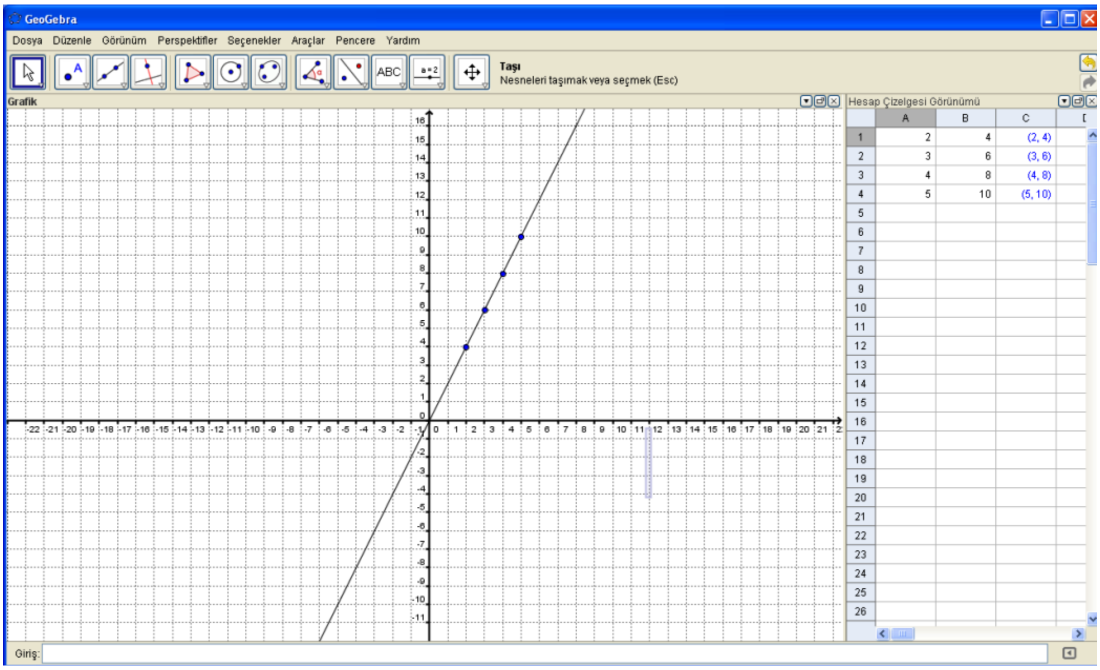

Figure 6 An example from a student's GeoGebra file on linear relation

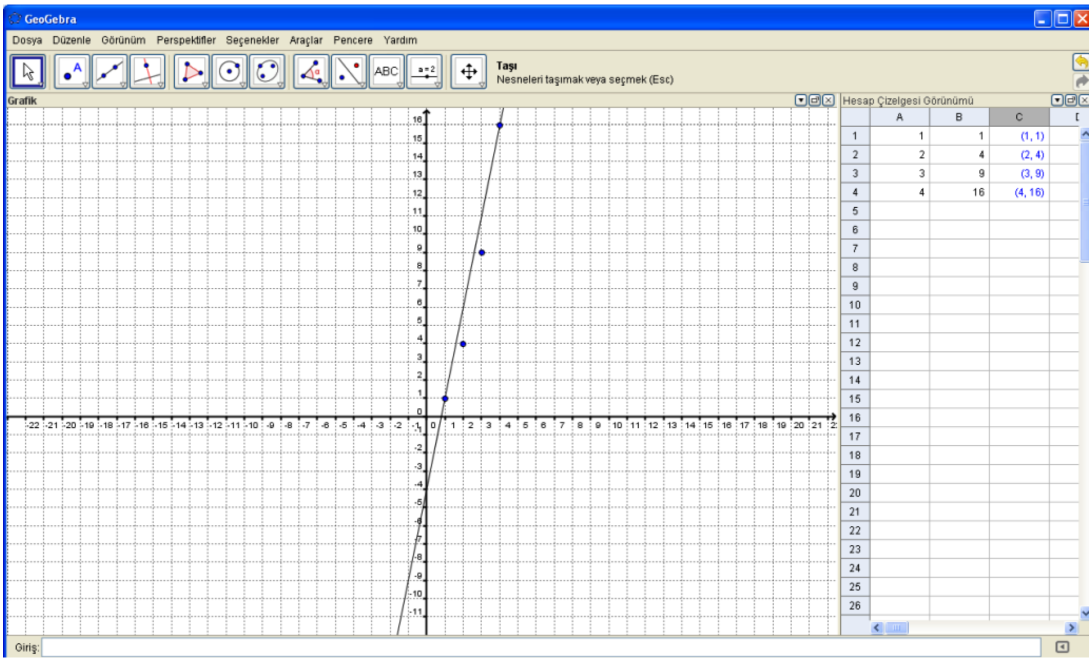

Figure 7 An example from a student's GeoGebra file on nonlinear relation

On the other side, the control group filled the table which were given on the activity sheet and then, put the points on the coordinate plane. After that, the students connected the points by a ruler to check whether there was a linear relation or nonlinear relation between given variables on the table (Figure 8).

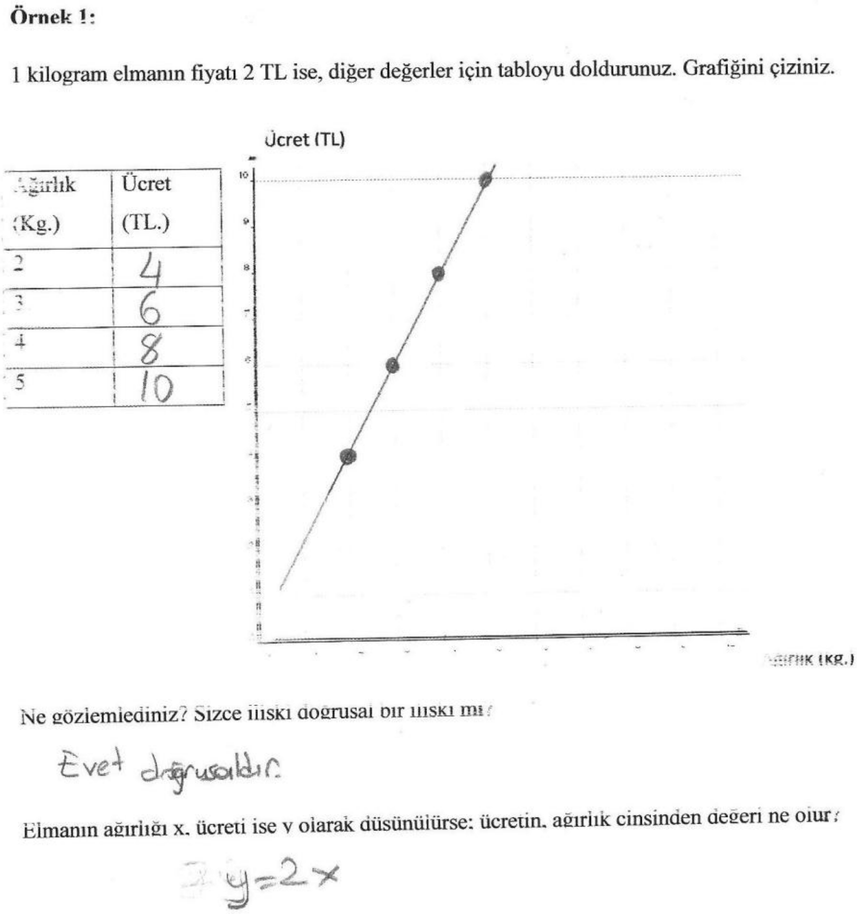

Figure 8 Example on Drawing Graph of Linear Relation

3.6.3 Graph of Linear Equation

In the previous sessions, first, a table was formed; then, the symbolic representation was examined according to the table. Differently, in this part of the treatment, symbolic representation of a linear equation was given and students were asked to make a table, and then to draw its graph.

Experimental group filled the table using the GeoGebra's spreadsheet part; the points were automatically put on the coordinate plane. After connecting the points with a line, the symbolic representation of the equation was examined under the algebraic view of the GeoGebra. Students investigated the relationship between tabular, symbolic and graphical representations of the equations by changing the variables on the table or manipulating the graphs.

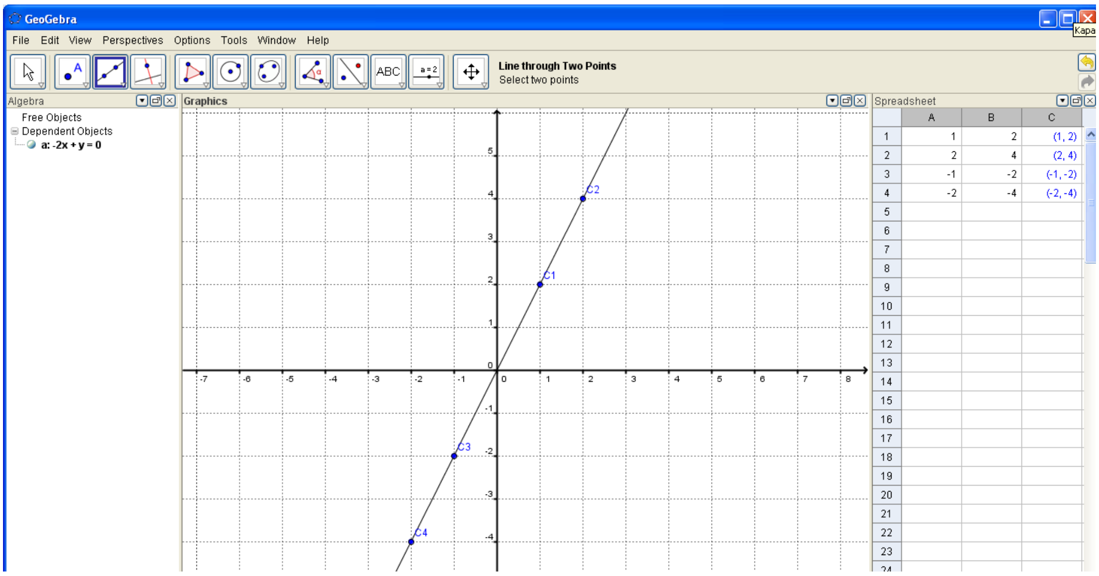

Figure 9 Symbolic, graphical and tabular representation of an equation in GeoGebra

Furthermore, the experimental group examined the differences among the graph of the equations of the form $y=mx$, $y=mx + n$ and $y = c$. They wrote 5 equations for each form in the input part, and they examined the graphs of these equations and also they saw the algebraic form of the equations on the algebra window (Figure 10). Then, they were directed to reach a generalization for lines, which were in the form of $y=mx$, pass through origin, $y=mx + n$ intercept the axes and $y= c$ were parallel to the axes.

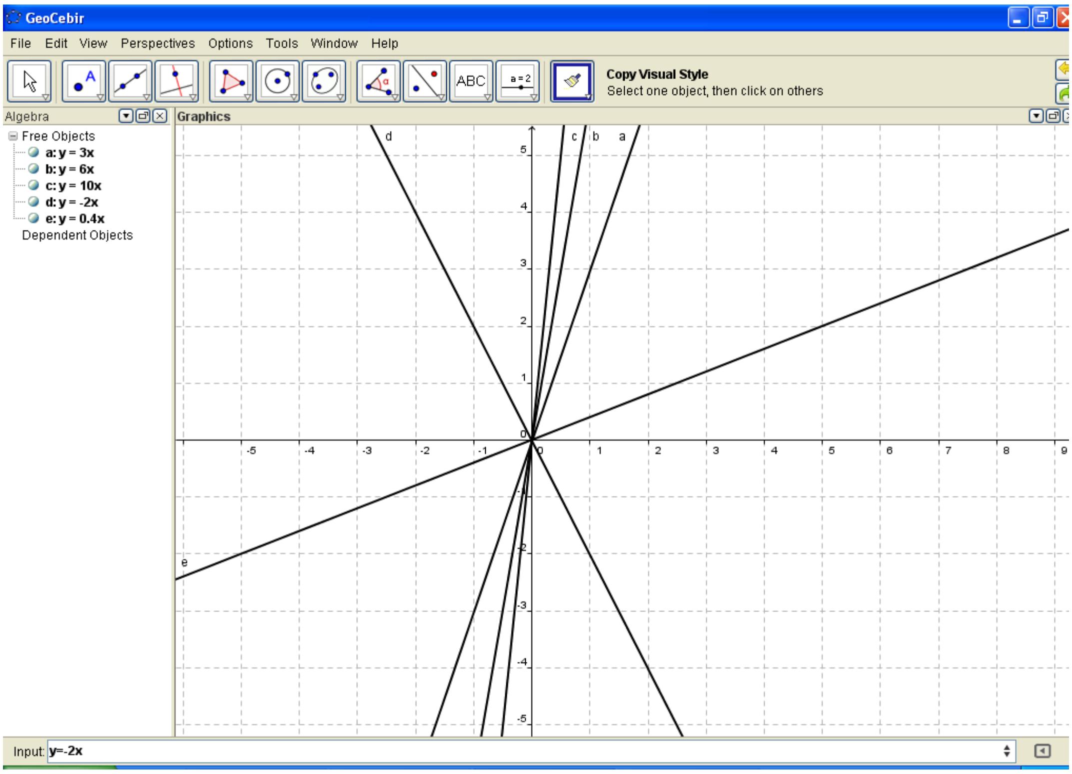

Figure 10 The lines passing through origin in GeoGebra

Control group examined the same equations which were given in symbolic representation by making a table and then drawing their graphs. However, the examples were limited with equations only on the activity sheets. They did not have chance to examine the effects of manipulation of one of the three representations on the other two representations. The possible results of these manipulations were explained by the instructor.

3.7 Analysis of Data

Quantitative data analysis was used to examine the data collected from the Mathematics achievement tests. For analyzing the data, PASW 18 statistics program was used. A quantitative data analysis is classified as descriptive and inferential statistics.

In order to investigate the general characteristics of the sample, descriptive statistics which are mean, median, standard deviation, skewness, kurtosis, maximum and minimum values of the data were examined for both experimental and control groups.

To examine the differences between the mean scores of the groups on MAT1, MAT2 and MAT3 while controlling readiness test scores, Analysis of Covariance (ANCOVA) was used for each test. The hypotheses were tested at the level of significance 0.05.

3.8 Internal Validity

Some possible internal validity threats, such as subject characteristics, mortality, location, history, testing and implementation, were discussed for the present study.

Since students were randomly assigned to the groups, subject characteristics could not be a problem for this study. In addition, it was presented that students were at same grade level and also their socioeconomic level was almost same.

Similarly, mortality is also not a threat for this study. 60 students from three different classes participated in this study as volunteers. Therefore, all students continued the treatment and also the tests were administered to all of them without missing.

In addition, the test was implemented to the students in their regular classrooms at the same time. All seventh grade classrooms were on the same floor and they had almost same conditions. Therefore, location was also not a threat.

Since the researcher was also the instructor, an observer observed all lectures during the treatment and took notes meticulously in order to examine the researcher bias. According to these notes and the observer's opinion, the only difference between groups was the tools used which was GeoGebra for experimental group and paper-pencil for the control group. Therefore, it can be said that any differences between mathematics achievement tests scores of both groups would be derived from usage of GeoGebra.

There was a possible confounding variable which was students' attitudes toward the researcher. Since the researcher was also their teacher, the researcher was already had known by the students. It was possible that some students had positive attitude, on the other hand some of them had negative attitude toward her. This cannot be controlled or prevented. Hence, their attitudes might have affected the results.

3.9 External Validity

The accessible population of the study was the seventh grade students of a public school in Yenimahalle district of Ankara. Since the school was chosen conveniently, the results presented in this study cannot be generalized to a larger population regarding external validity. However, the results can be applied to a larger population of samples which have similar characteristics with the sample of this study. The tests were administered in regular classroom settings during the regular lesson hours. There were three classes with around 20 students each. The conditions of the classrooms were quite similar, the sitting arrangements and the lighting were equal in three classrooms. Thus, the threats to the ecological validity were controlled.

3.10 Limitations

This study is limited to seventh grade students in a public school in Yenimahalle district of Ankara. In addition, the number of participants is limited with 60 students; therefore the results cannot be generalized to the population.

The study continued only three weeks during the 2011-2012 academic years. The topics were limited with Cartesian coordinate system, linear relations and graph of linear equation. Therefore the results cannot be generalized to the other subjects.

3.11 Assumptions of the Study

Four assumptions are listed as follows:

- All instruments were administered to both control and experimental group students under the same conditions.
- The participants of the study were honest while answering the tests.
- The participants in the study represent typical seventh grade students.
- Control and experimental group students did not interact and communicate about the treatments and the tests.

CHAPTER 4

RESULTS

This chapter presents descriptive statistics and inferential statistics related with the mathematics achievement tests.

4.1 Descriptive Statistics

Descriptive statistics about the readiness test (RT) and mathematics achievement tests, MAT1, MAT2, MAT3, are presented in the Table 8. The mean of RT was 8.17 (*SD*=3.22) for control group while the mean of RT was 7.60 (*SD*=3.28) for experimental group out of 15. Therefore, mean scores of the control group in the RT, which was administered prior to the treatment, were relatively higher than that of the experimental group. The means of control group in MAT1 (*M*=2.53, *SD*= 1.55) and MAT2 (*M*= 3.07, *SD* = 1.53) were relatively higher than the means of experimental group (MAT1: *M*= 2.17, SD = 1.51; MAT2: *M*= 2.87, *SD* = 1.55). On the other hand, the mean of MAT3 for experimental group (*M*= 2.19, *SD* = 1.34), was higher than the mean of MAT3 for control group (*M*= 1.27, *SD* = 0.87). In addition, the maximum value of MAT3 for control group was 3 out of 5 where the maximum values of MAT1 and MAT2 were 5 for both control and experimental groups.

Table 8 Descriptive Statistics Related with Readiness test and MATs

Group	Variable	N	Mean	SD	Skewness	Kurtosis	Min.	Max.
CG	MAT1	30	2.53	1.55	.08	-.95	0	5
	MAT2	30	3.07	1.53	-.24	-1.10	0	5
	MAT3	30	1.27	.87	.47	-.21	0	3
	RT*	30	8.17	3.22	-.04	-.64	2	14
EG	MAT1	30	2.17	1.51	.21	-.84	0	5
	MAT2	30	2.87	1.36	.17	-.71	0	5
	MAT3	30	2.19	1.34	.42	-.91	0	5
	RT*	30	7.60	3.28	.48	-.51	3	15

* Pre-administrated

In addition, clustered box plot was drawn by PASW 18 program. The box plot of MAT1, MAT2 and MAT3 are shown in Figure 11. As it is seen, the total score of MAT2 was higher than MAT1 and MAT3 scores for both groups. However, the difference between MAT1-MAT3 and MAT2-MAT3 for control group was bigger than the difference between same tests in experimental group.

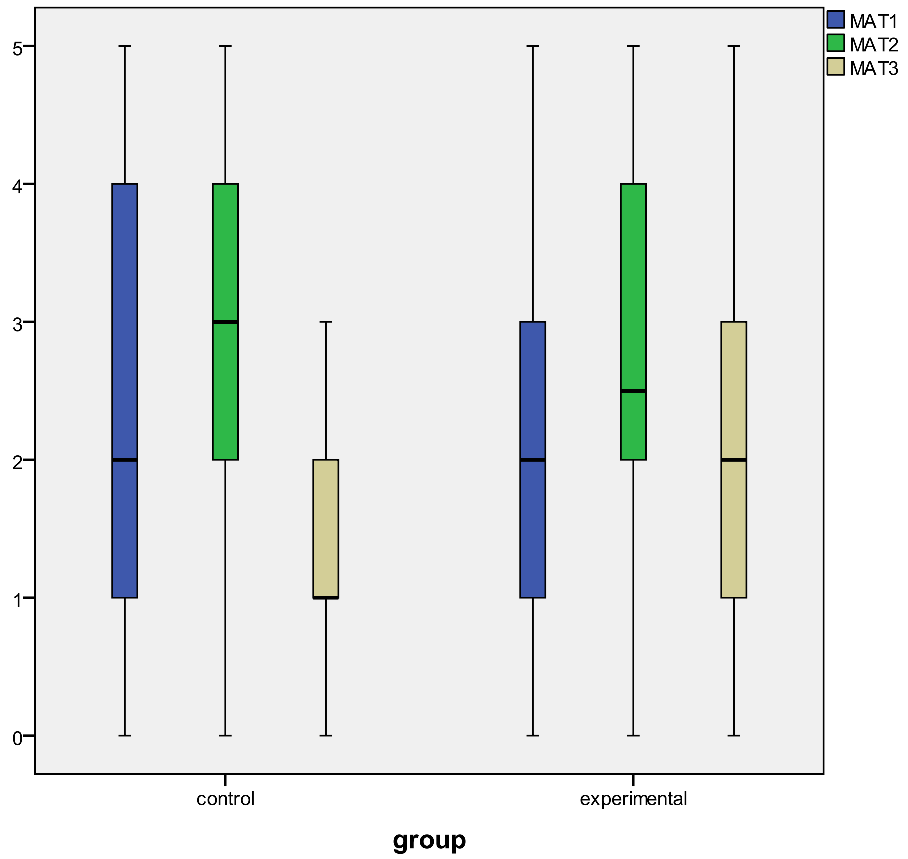

Figure 11 Clustered Box plot of the MAT1, MAT2 and MAT3

4.2 Inferential Statistics

Analysis of Covariance (ANCOVA) was conducted to explore the differences between the MAT1, MAT2 and MAT3 scores of experimental and control group.

4.2.1 Missing Value Analysis

There were no missing value in readiness test and three mathematics achievement tests.

4.2.2 Determination of the Covariate

Previous mathematics success level of students was determined as possible confounding variable which might influence the students' mathematics achievement tests' scores. This level was measured before the treatment by readiness test. Therefore, Readiness test scores were taken as covariate in order to control the preexisting differences between the groups. The correlation between readiness test scores and mathematics achievement tests scores were examined. The result of Pearson product-moment correlation coefficient was found as .47 for MAT1, .60 for MAT2 and .46 for MAT3. According to Cohen (1988), the value from .30 to .49 shows medium and .50 to 1.0 shows large correlation (as cited in Pallant, 2007). Thus, the correlation between readiness test and MAT1 and also readiness test and MAT3 is medium where the correlation between readiness test and MAT2 is large.

4.2.3 Assumptions of ANCOVA

The assumptions which are needed to be verified are listed below:

1. Independency of observations

2. Normality

3. Measurement of the covariate

4. Reliability of the covariate

5. Homogeneity of Variance

6. Linearity

7. Homogeneity of regression

The researcher observed both groups during the administration of the readiness test and Mathematics achievement tests. According to observations, it was concluded that the participants answered the tests on their own.

In order to check the normality assumption, skewness and kurtosis values of MAT1, MAT2 and MAT3 were examined. The values are presented in the Table 8. There was a normal distribution according to skewness and kurtosis values which were in acceptable range, -2 and 2 (Kunnan, as cited in Hardal, 2003).

In this study, readiness test scores were determined as covariate. It was measured before the treatment. The pre-administration of the test provided the control of measurement of covariance assumption.

The reliability of the readiness test as a covariate was calculated as .71. This value is above .70, which implies that the test was reliable.

The homogeneity of variances was controlled by Levene’s Test of Equality. The results are shown in Table 9.

Table 9 Levene’s test of equality of error variances for MAT1, MAT2 and MAT3 scores for the experimental and control group

	F	df1	df2	Sig.
MAT1	.07	1	58	.80
MAT2	.06	1	58	.80
MAT3	5.04	1	58	.03

As it is seen in Table 9, the significance value is greater than .05 for MAT1 and MAT2. Therefore, it is indicated that the assumption of homogeneity of variance had not been violated these two test. However, the significance value is less than .05 for MAT3. Thus, the assumption is violated for this test. According to Stevens (1996), if the sizes of the groups are approximately equal, F is robust. Since the size of the groups was equal for this research, it is assumed that F is robust (as cited in Pallant, 2007).

To check the linearity assumption, scatter plots between the dependent variables and the covariate were generated. Figure 12 Figure 13 and Figure 14 show the scatter plots generated for linearity assumption.

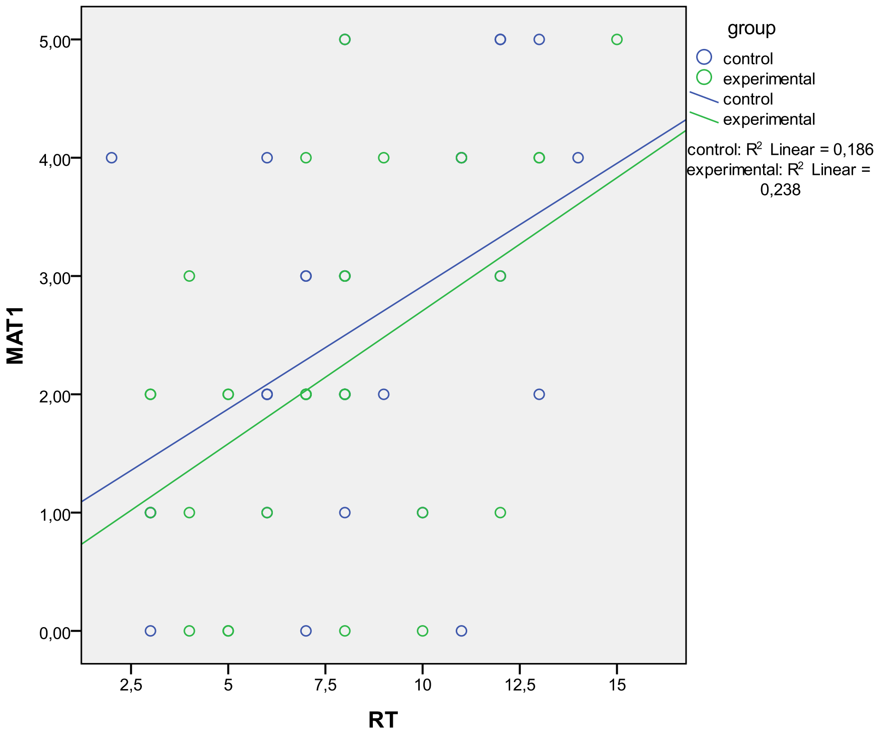

Figure 12 Scatter plot between RT and MAT1

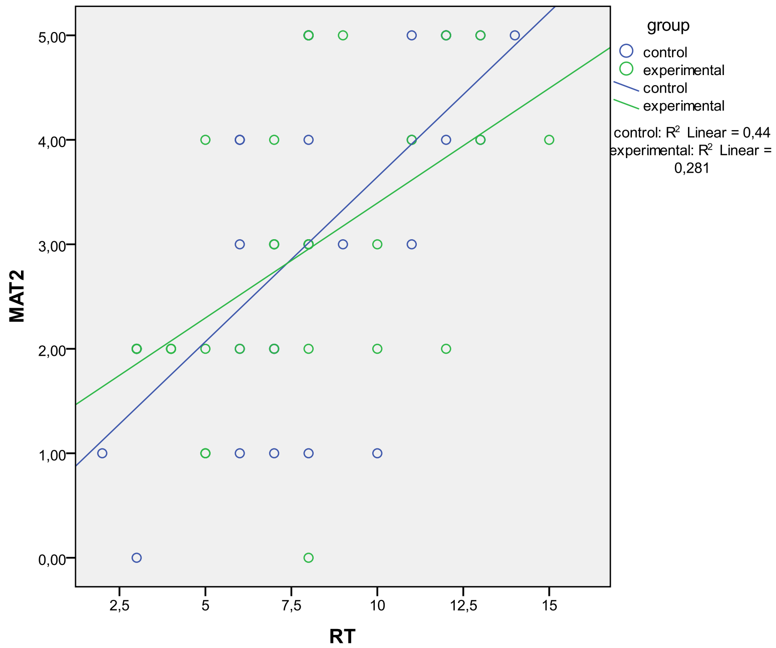

Figure 13 Scatter plot between RT and MAT2

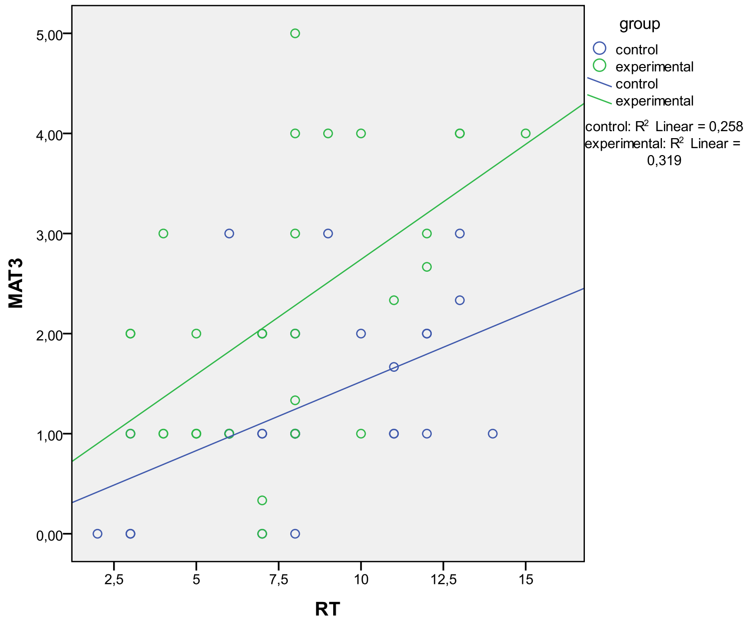

Figure 14 Scatter plot between RT and MAT3

As seen on the scatter plots, there were linear relationships. Since the relationships were linear, linearity assumption was not violated.

To examine homogeneity of regression assumption, interaction between the groups and readiness test scores was checked. The results are shown on Table 10.

Table 10 Interaction between the Groups and RT

Dependent variable	Source	sum of squares	Df	F	sig
MAT1	Group*RT	.046	1	.024	.878
MAT2	Group*RT	1.396	1	1.023	.316
MAT3	Group*RT	1.304	1	1.414	.239

As it is seen on Table 10, the p values are greater than .05. Therefore; there is no interaction between groups and readiness test scores. Therefore, homogeneity of regression assumption was met.

4.2.4 ANCOVA for MAT1

The following null hypothesis was checked for the first analysis.

Null Hypothesis 1: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on Cartesian coordinate system after controlling their readiness test scores.

The results of the analysis are presented in Table 11.

Table 11 Result of the ANCOVA for MAT1

Source	Type III sum of squares	Df	F	Sig.	Partial eta squared
RT	28.644	1	15.261	.000	.211
Group	.886	1	.472	.495	.008
Error	106.989	57			
Total	469.000	60			

As seen on Table 11, there was no statistically significant mean differences between experimental (*M*= 2.17, *SD* = 1.51), and control groups (*M*=2.53, *SD*= 1.55) with respect to MAT1 scores on Cartesian coordinate system, $F(1,57)= .47$, $p= .50$, partial eta squared= .008. This means that GeoGebra usage had no significant effect on students' achievement in Cartesian coordinate system.

4.2.5 ANCOVA for MAT2

The next null hypothesis tested was the following.

Null Hypothesis 2: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on linear relations after controlling their readiness test scores.

The results of the analysis are presented in Table 12.

Table 12 Result of the ANCOVA for MAT2

Source	Type III sum of squares	Df	F	Sig.	Partial eta squared
RT	43.494	1	31.850	.000	.358
Group	.036	1	.026	.872	.000
Error	77.839	57			
Total	650.000	60			

As it is seen on Table 12, there was no statistically significant mean difference between experimental (*M*= 2.87, *SD* = 1.55) and control groups (*M*= 3.07, *SD* = 1.53) with respect to MAT2 scores on linear relations, $F(1,57) = .03$, $p = .87$, partial eta squared $\leq .01$. This means that GeoGebra usage had no effect on achievement in linear relations.

4.2.6 ANCOVA for MAT3

The last analysis tested the following null hypothesis.

Null Hypothesis 3: There will be no significant difference between the means of the two groups' scores on mathematics achievement test on graph of linear equations after controlling their readiness test scores.

The results of the analysis are presented in Table 13.

Table 13 Result of the ANCOVA for MAT3

Source	Type III sum of squares	Df	F	Sig.	Partial eta squared
RT	20.861	1	22.463	.000	.283
Group	15.694	1	16.899	.000	.229
Error	52.935	57			
Total	265.667	60			

As it seen on Table 13, there was a statistically significant mean difference between experimental (*M*= 2.19, *SD* = 1.34) and control groups (*M*= 1.27, *SD* = 0.87) with respect to MAT3 scores on graph of linear equation, $F(1,57)= 16.90$, $p= .00$, partial eta squared= .23. Partial eta squared indicates a large effect size. In other words, 22.9 percent of the variance in the MAT3 scores was explained by the treatment. This means that GeoGebra usage had a significant effect on achievement in graph of linear equations positively.

4.3 Summary of the results

Descriptive statistics related with the readiness test and mathematics achievement tests, MAT1, MAT2, MAT3, are presented in the Table 8. There was a slight mean difference between control and experimental group students' RT, MAT1 and MAT2 scores in the favor of control group. On the other hand, mean scores of MAT3 of the experimental group students was higher than control group students' mean scores of MAT3.

According to ANCOVA results for MAT1 and MAT2, no significant difference was found between the groups when RT scores were controlled. The only significant difference between groups was found on MAT3 scores when RT scores were controlled. The mean score of MAT3 of experimental group (*M*= 2.19, *SD* = 1.34) was significantly higher than the mean score of MAT3 of control group (*M*= 1.27, *SD* = 0.87).

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the effects of using Dynamic Mathematics Software (GeoGebra) on seventh grade students' achievement in linear equations. Linear equation topic includes three subtopics which are Cartesian coordinate system, linear relations and graph of linear equation in Turkish elementary mathematics curriculum. In the current study, achievement of seventh grade students in each of these subtopics was measured through three achievement tests, namely MAT1, MAT2, and MAT3. The following section includes a discussion of the results related to each of these achievement tests.

5.1 Students' Achievement in Cartesian Coordinate System

During three hours, students in experimental group recognized elements of Cartesian coordinate systems such as ordinate, abscissa, origin and region; found points on Cartesian coordinate plane, and determined the coordinates of the point which were a part of a shape on the graphical screen of GeoGebra. Similarly, the students in the control group experienced same procedures on the paper. The results of Mathematics Achievement Test 1 revealed that there was no significant difference between the groups in terms of their achievement in the use of Cartesian coordinate system. This means that GeoGebra had no effect on students' achievement in Cartesian coordinate system. One possible reason is that the nature of the subject and activities did not allow for the applications of the main property of GeoGebra which is dynamic changeability. In other words, the activities did not provide explorations since they involved deciding about location of points and recognizing elements of Cartesian coordinate system.

5.2 Students' Achievement in Linear Relations

During the treatment, students in both groups transformed representation of a linear relation from tabular to graphical and also tabular to symbolic. Furthermore, they compared linear and nonlinear relations by examining symbolic and graphical representations of relations. Inferential statistics revealed that there was no significant difference between the control group and the experimental group students' achievement in linear relation which was assessed by Mathematics achievement test 2. The reason of this may be derived from students' adequate preliminary knowledge on finding rule of pattern and line graph which were learned previously. In sixth grade, students are required to make transitions between tabular and symbolic representations when they find general term of a given pattern. Besides, since students need to make transition from tabular to graphical representation when constructing a line graph, they developed familiarity with line graphs beginning from the early grades of elementary school.

Students' performances related to linear relations were measured by 14^{th} and 15^{th} questions in the readiness test (see Appendix C). In 14^{th} question students were asked to transform the relation from graphical to tabular and in 15^{th} question they were asked to transform the relation from tabular to symbolic representation Descriptive statistics showed that 67% of the students in the control group and 63% of the students in the experimental group gave correct answer to these two questions. These percentages can be considered as indicators of students' preliminary knowledge related to these concepts.

Even if the inferential statistics revealed that GeoGebra did not have any effect on students' achievement in linear relations, some differences related to drawing graphs were detected in students' works. It was noticed that students in control group were in trouble about drawing of a relation's graph. As seen in Figure 15, while plotting the data on the table in the coordinate system, most of the students put points bigger than necessary. Therefore, when they connected the points, they did not notice the nonlinearity and they drew a line even it represent a nonlinear relation such as $y=x^2$. However, this situation was not seen in the works of students in experimental group due to the accuracy of GeoGebra. The accuracy or automaticity here was provided by the feature of the software as requiring only the entry of data and representing the data in graphical view automatically and precisely.

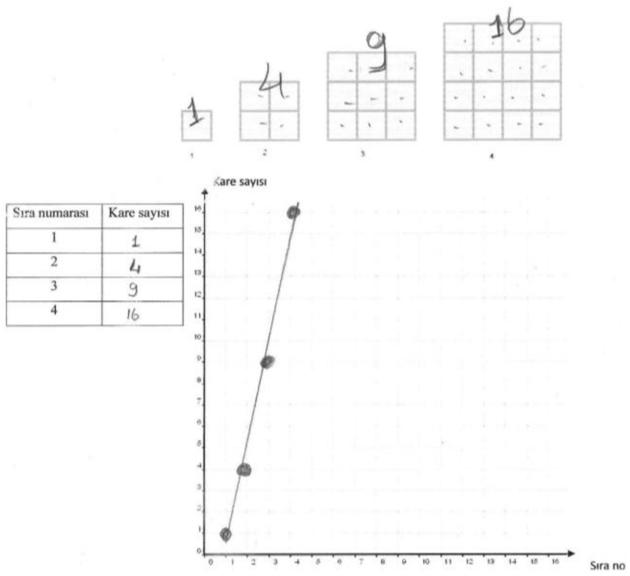

Figure 15 An example of a control group student’s drawing of a nonlinear relation, $y=x^2$

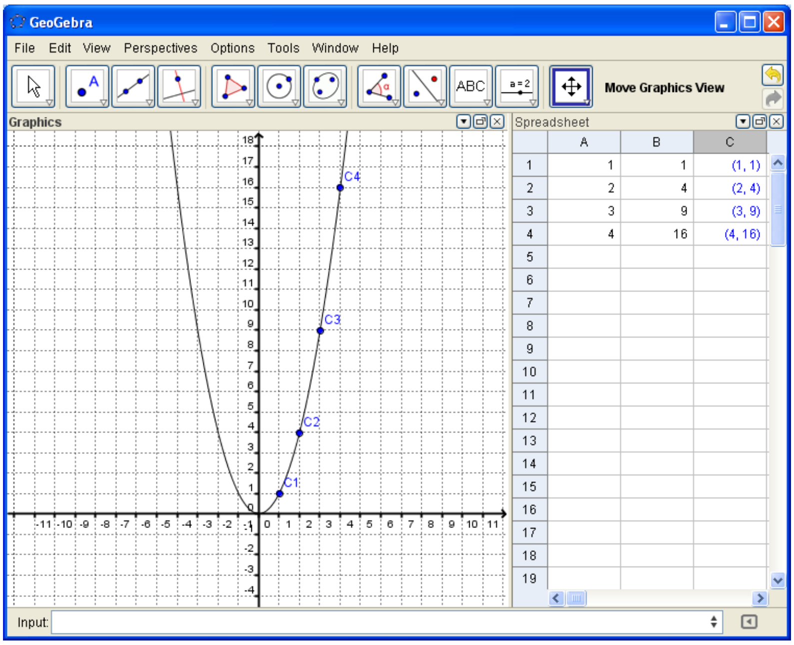

Figure 16 An example of an experimental group student’s drawing of a nonlinear relation, $y=x^2$

5.3 Students' Achievement in Graph of Linear Equations

During the treatment, students in both groups transformed representation of a linear equation from symbolic to tabular and then tabular to graphical. Moreover they examined symbolic representation of linear equations of which graphs were passing through origin or intercepting the axes.

The results of Mathematics achievement test 3 revealed that there was a statistically significant difference between the groups in terms of their achievement in drawing graph of linear equation in favor of dynamic mathematics software-based instruction. The possible reason of this result is that experimental group students had a chance to examine three representations, namely tabular, algebraic and graphical, on the same screen as GeoGebra provided opportunity to examine the relationship between representations at a glance. Importance of multiple representations for understanding algebra comprehensively is stressed in many studies where they indicated that proper understanding of a mathematics concept requires using these representations and transition ability between these representations (Ainsworth, 1999; Lesh, Post, & Behr, 1987). The simultaneous examination of the relationships between these representations through GeoGebra made experimental group students to get higher scores from MAT3. This result is consistent with the Borba and Confrey's (1996) results who investigated relation between graphs and tabular representations and also relation between graph and algebraic representation by using Function Probe. Their case study pointed out that powerful form of cognition of function concept requires visual reasoning and seeing graphical transformations as movements which are forms of multiple representations. Similarly, in this study, students in the experimental group had the opportunity to see the movements in the graphical representations while symbolic and tabular form of an equation changes.

Besides, in his study, Pilipezuk (2006) concluded that there was no significant effect of calculator-based laboratory activities on students' understanding of function concept in terms of quantitative results yet the qualitative analysis results revealed that experimental group students outperformed control group students on graphing function similar to the result of this study.

Moreover, Hines (2002) concluded that dynamic physical model, which was formed using *a spool elevating system, and an Etch-a-Sketch™ toy,* helped the student to improve his understanding of linear function. These physical models allowed for examining different representations of linear equations as GeoGebra's done. Therefore, the results of current study are consistent with the findings these studies.

Although MoNE (2009) stresses the importance of multiple representations, the objective and also the title on the textbook are related only drawing graph of linear equations. Since lesson plans were prepared according to textbook, it was observed that according to control group students, translating of a linear equation from tabular representation to symbolic representation is just a finding rule of a pattern and tables are just a tool to draw a graph not another representation of the same relation. Even similar activities were applied for the experimental group; experimental group students had a chance to see three different representations of a linear equation at the same screen. Therefore, experimental group students could link between these representations.

5.4 Discussion for technology-based instruction

Besides the positive effects of GeoGebra usage, the instructor had two difficulties. These were related with substructure of computer laboratory of the school and class-size. Firstly, the computers in the laboratory had been used for ten years. The computers were very old for effective usage. The instructor checked every computer before each class with another instructor of the school. Some minor technical problems occurred during the treatment, but since the observer was instructor of computer technologies, she intervened in the problem. Therefore these problems did not affect the study. However, if the instructor were alone, technical problems could have taken time and, most probably, it would have a negative effect on instruction. This study confirmed that infrastructure of computer laboratory is very important to construct an effective learning environment.

Second difficulty was related with class size. In the study, the groups were formed with 30 students. Because of the technical problems and students' excitement in the experimental group, classroom management was an important issue. The instructor made so much effort to manage the class. Therefore, it can be concluded that studentcentered technology-based instruction is not suitable for 30 students or more from the point of classroom management.

5.5 Implications of the study

The results of this study showed that using GeoGebra in graph of linear equations had positive effects on students' achievement. Transition among different representations of a linear equation is an important dimension of conceptual understanding. In this study, GeoGebra gave opportunities to realize that a linear equation can be represented in different ways. In other words, students were able to examine different representations of equations and transition between them through GeoGebra. Therefore, teachers should use this software while they instruct graph of linear equations in their lessons. In addition, curriculum developers and textbook writers should incorporate such kind of activities which are based on dynamic mathematics software into the curriculum and textbooks for graph of linear equations. Furthermore, dynamic mathematics software should be used for different mathematics subjects which require examination of multiple representations such as slope, inequality.

5.6 Recommendations for Further Research

This study focused on linear equation topic on seventh grade, thus the results cannot be generalized to the other grade levels and other algebra topics. Further research should be conducted at different grade level and different algebra topics.

This research was limited with three weeks. Further research should be conducted to investigate long term effects of GeoGebra usage on students' achievement in all algebra content area.

The topic of linear equation is mostly related with other subjects like Science. Therefore, the effects of GeoGebra usage on Science lessons should be investigated and comparison with GeoGebra usage on mathematics lessons should be further research issues.

This study was limited with quantitative data, in order to understand the effects of dynamic mathematics software programs in depth, using qualitative approaches such as observation and interviews are suggested.

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APPENDICES

APPENDIX A. LESSON PLANS

LESSON PLAN 1

Unit 4: Algebra and Probability

- Equations

Grade level: 7

Duration: 40 + 40 + 40 min.

Objectives:

- ✓ Students should be able to give examples about daily life usage of “ordered pair”
- ✓ Students should be able to explain the elements of Cartesian coordinate systems which are ordinate, abscissa, origin and region.
- ✓ Students should be able to find points on the Cartesian coordinate system.
- ✓ Students should be able to estimate the coordinates of the point which is a part of a shape.

Part 1:

Duration: 40 min.

Purpose: “Ordered pair” concept is comprehended by giving examples of its daily life usage. Also the elements of Cartesian coordinate system which are ordinate, abscissa, origin and the regions are introduced.

To attract students attention cinema.gif is shown to students and asks whether they have ever gone to the cinema or not.

Figure: cinema.gif

It is wanted to remember what is written on the cinema ticket which shows their seat. There is a letter and a number. Cinema_plan.gif is shown. It is emphasizes that a person cannot reach his seat first finding number and then letter, since there is no gap between seats. So, order is important.

Figure: Cinema_plan.gif

Polislojmanları.gif is shown, and it is wanted from a student to direct his/her flat. (For example E8). It is again stressed that there is a pair and first is name of block and the second is the number of door. Reverse is meaningless. So, order is important.

Figure: Polislojmanları.gif

Lastly, longitude and altitude are remembered and Turkey.gif is shown. It is asked to students; if a person is on the 38° north longitude and 31° east altitude, in which city is he? (He is in Afyon)

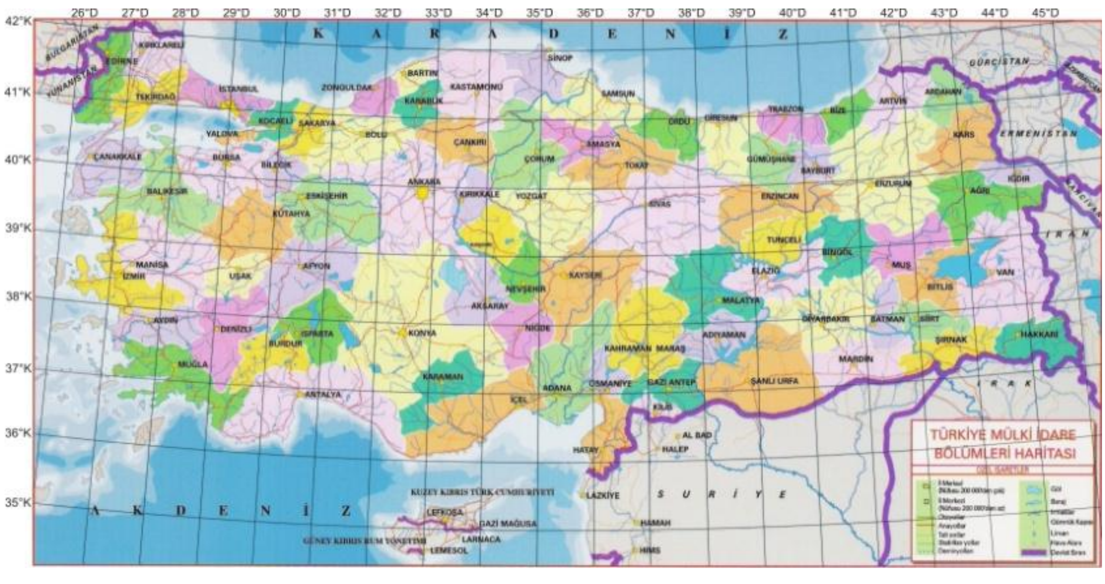


Figure: Turkey.gif

After these three examples are given, it is emphases that “ordered pairs” are used to find a place.

It is asked to students open the “*koordinat*” GeoGebra file. Cartesian coordinate system is introduced on this file.

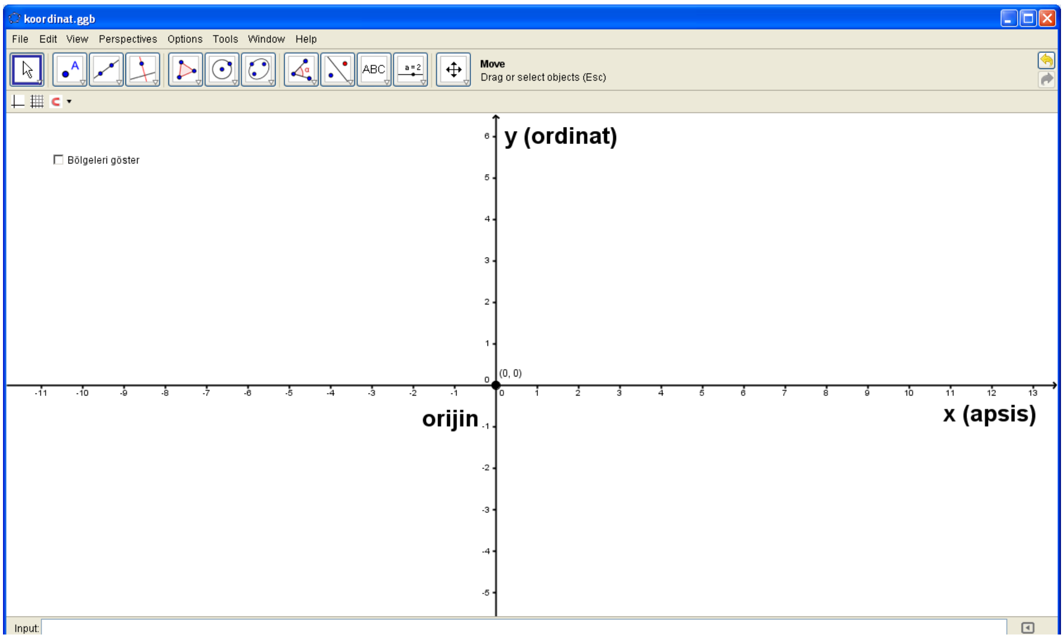


Figure: koordinat.ggb

To see regions, it is wanted to click the regions box at the left top corner.

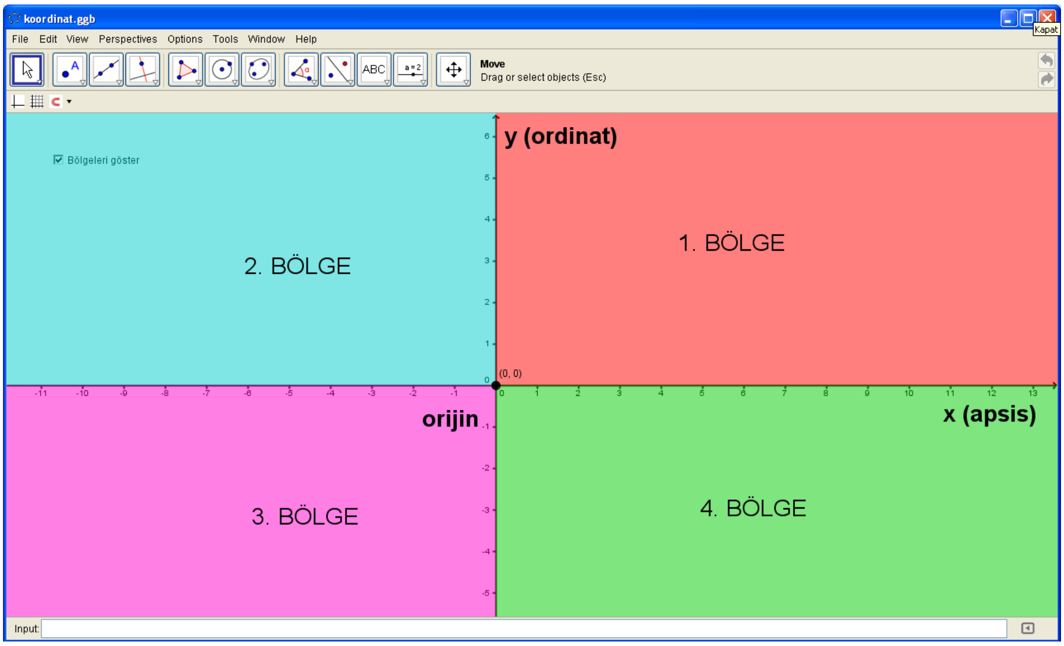


Figure: koordinat.ggb after marking “see the region” tickbox

Part 2:

Duration: 40 min.

Purpose: The places of points are found on the Cartesian coordinate system by help of their coordinates. In addition, the signs of coordinate of points are investigated with respect to their regions.

The place of a point on the Cartesian coordinate system is represented by ordered pair, (x, y).

"*koordinat 1.bölge*" GeoGebra file is opened and an example is shown. For example, to find A(3, 4), the horizontal slider which represents abscissa is slided to 3, and then the vertical slider which represent ordinate is slided to 4.

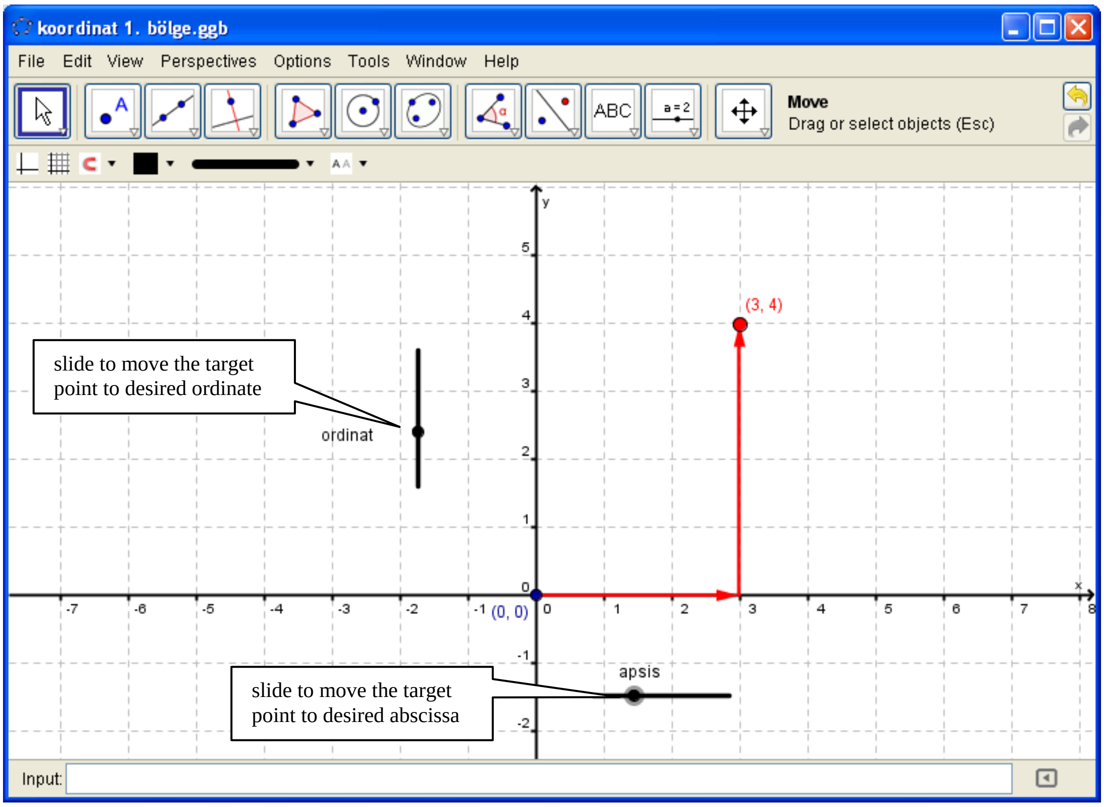


Figure: koordinat 1.bölge.ggb

Activitysheet 1 is distributed.

Points in the activity sheet are found by using "*koordinat 1.bölge*" GeoGebra file, and then the points are drawn on the coordinate system on the activitysheet1. Enough time is given to students to complete all points. After completing, the instructor shows the points. The signs of coordinates of the points are discussed and written on the activity sheet.

The same procedure is repeated with "*koordinat 2.bölge*", "*koordinat 3. bölge*" and "*koordinat 4. bölge*" GeoGebra files.

Part 3:

Duration: 40 min.

Purpose: Students make practice about finding points on Cartesian coordinate system. Students guess the place of the points to construct a shape or picture.

Usage of input box is introduced to students to find points. Also how the points are connected by a sector is shown. It is wanted from the students to make any picture they want such as umbrella, house, car, tree…etc. An example is shown by the instructor. Instructor uses input box to draw a house or a tree like in the below example. The important point is guessing the place of the next point to construct a house or tree.

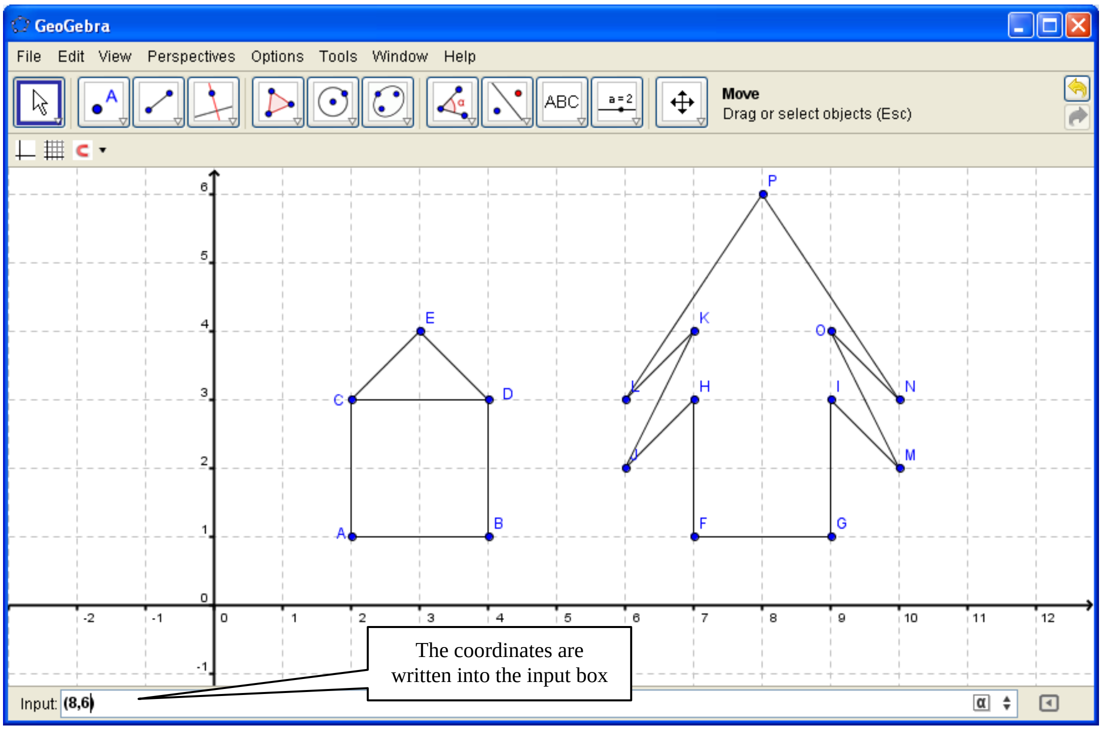


Figure: koordinat 1.bölge.ggb

Then students' works are checked during the class hour, in last 10 minutes, some of them are represented to the whole class.

LESSON PLAN 2

Unit 4: Algebra and Probability

- ➢ Equations

Grade level: 7

Duration: 40 + 40 + 40 min.

Objectives:

- ✓ Students should be able to explain linear relations.
- ✓ Students should be able to transform representation of a linear relation from tabular to symbolic representation
- ✓ Students should be able to transform representation of a linear relation from tabular to graphical representation
- ✓ Students should be able to compare linear and nonlinear relations according to their symbolic representations
- ✓ Students should be able to compare linear and nonlinear relations according to their graphical representations

<u>Part 1:</u>

Duration: 40 min.

Objective:

- ✓ Students should be able to transform representation of a linear relation from tabular to symbolic representation

The lecture starts with reviewing the prerequisite knowledge of the students about the relations in patterns.

"activitysheet2" is distributed to students. Also it is projected to the board. There are 5 examples and each example is done in order. The patterns are found and discussed whether there are relations or not.

E.g.1:

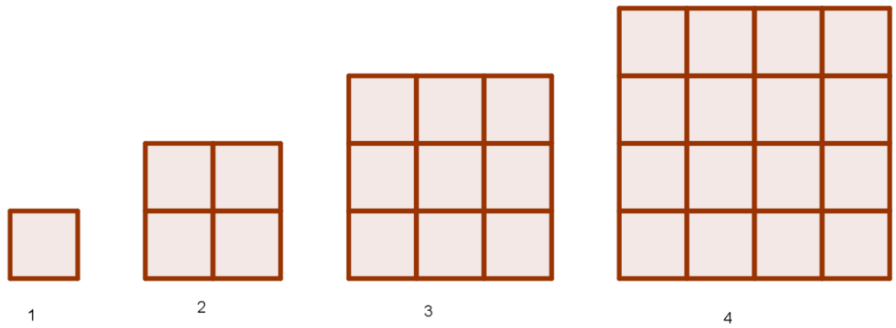
If an automobile drives 60 km in an hour, what can be the relation between road and time? Show it in a table.

The answer is:

time	1	2	3	4	5	….	n
road	60	120	180	240	300	….	60.n

E.g. 2:

What is the relation between sequence number and number of squares?



The answer is:

Sequence	1	2	3	4	…	n
Number of squares	1	4	9	16	…	n^2

Eg 3:

A taximeter is opened with 130 Kr. and it increases 130 Kr. for each kilometer. What is the relation between road and its paying?

road (km.)	Pay (Kr.)
1	130+1.130
2	130+2.130
3	130 +3.130
n	130+n.130

Eg 4:

A waiter get tip; for first day 10 TL, for second day7 TL, for third day 16 TL and for fourth day 15 TL.. What is the relation between number of work and amount of tip?

Day of work	Tip (TL.)
1	10
2	7
3	16
4	15
n	?

There is no relation.

Eg 5:

A telephone company makes a campaign. According to this campaign, people can speak unlimited with paying 50 TL. monthly. What is the relation between speaking times and the pay?

Speaking time (dk.)	Pay (TL.)
1	50
2	50
20	50
150	50
n	50

<u>Part 2:</u>

Duration: 80 min.

Objectives:

- ✓ Students should be able to transform representation of a linear relation from tabular to graphical representation
- ✓ Students should be able to compare linear and nonlinear relations according to their symbolic representations
- ✓ Students should be able to compare linear and nonlinear relations according to their graphical representations

The questions are asked

- ! What do you think about linearity?
- ! Do you think the relations in these five examples are linear? And how do you decide it?

After discussing these questions, it is emphasized that whether a relation is linear or not can be understood by graphing it on the cartesian coordinate system.

After that, “*activitysheet3*” are distributed.

In the first part, there are five examples in the sheet. Firstly the students fill the table as just did previous lecture. It is wanted to think variables as (x,y) ordered pair. Students open a GeoGebra file and then arrange the spreadsheet view. The data on the table on the activity sheet is written on the spreadsheet. (x,y) ordered pairs are written at right column. The points which represent these ordered pairs are shown on the coordinate system automatically.

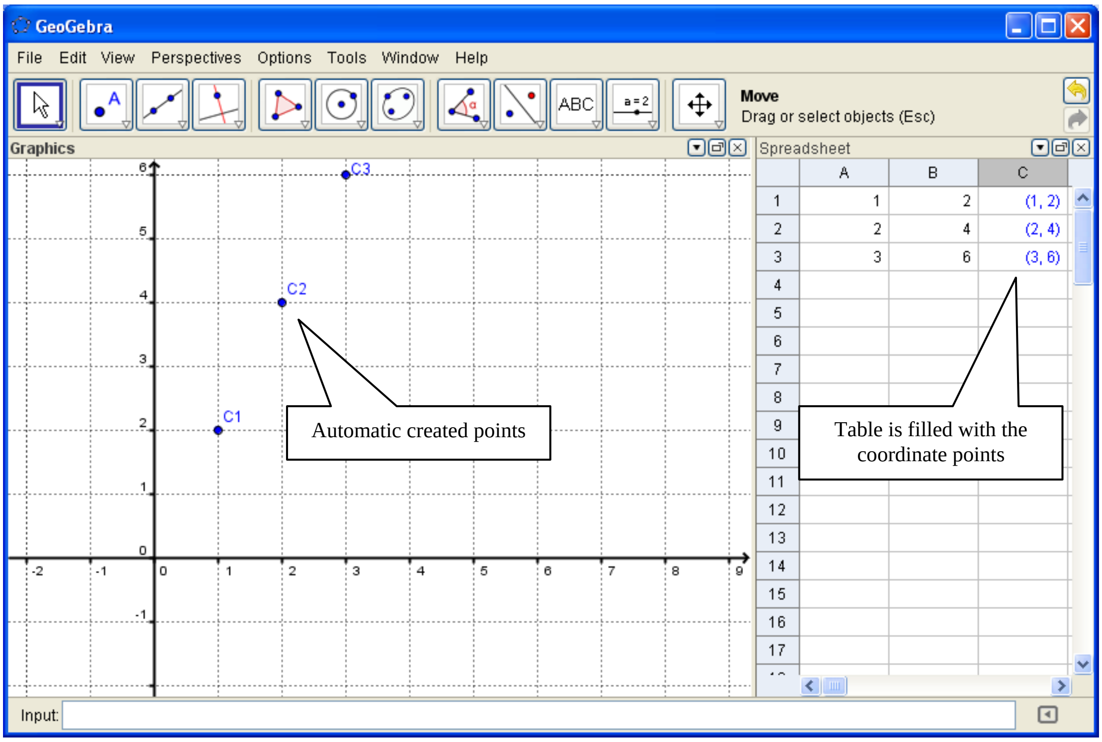
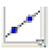


Figure: linear relation eg1

It is asked from the students to connect the points by a line using “line through two points” button.  The linearity of the relation is discussed according to its graph.

After drawing graph, symbolic representation of the relation is discussed and is written on the activity sheet.

The same procedure is repeated for relation 2, relation 3, relation 4, and relation 5.

Graphs of five relations are examined and compared whether they are linear or nonlinear relations according to their graphs.

In the part 2, linear and nonlinear relations are classified and the table is filled with their symbolic representations. The table is examined and it is expected that students realize linear equations are in the form of $y=ax+b$.

In the part 3, students put a cross near the linear equations.

LESSON PLAN 3

Unit 4: Algebra and Probability

- Equations

Grade level: 7

Duration: 40 + 40 + 40 min.

Objectives:

- ✓ Transform representation of a linear equation from tabular to graphical representation
- ✓ Transform representation of a linear equation from symbolic to graphical representation
- ✓ Explain the symbolic representation of a linear equation passing through the origin
- ✓ Explain the symbolic representation of a linear equation intercepting the axes.
- ✓ Find points on the graph of a linear equation
- ✓ Find the points which intercept the axes

Part 1:

Duration: 40 min.

Objective:

- ✓ Transform representation of a linear equation from tabular to graphical representation

The lecture starts with reviewing the previous lecture, linear relationship. How a relation is decided as a linear or not is discussed. Below examples are given, and the tables on the activity sheet is wanted to fill.

Example 1: We know "1 kg apple is 2 TL", so what about other values?

The answer is:

Kg of apple	Its price (TL)
2	4
3	6
4	8
5	10
…	…
x	2x

As it is seen on the table price of apple is 2 times of weight of the apple. In the previous lectures, we thought like weight of apple is x, and prize of it is y, then we concluded that y = 2x. We drew its graph on the coordinate system and saw its linearity.

y= 2x is a linear equation.

Example 2:

Fill the table with respect to number of sequence and number of triangle?

The answer is

Sequence number	Number of triangles
1	3
2	5
3	7
4	9
...	…
x	2x + 1

In the previous lecture, it was represented that the sequence numbers as x, and number of triangles as y. It was concluded that there is a linear relationship and y = 2x + 1 is a linear equation.

After remembering these two examples, the questions are asked and discussed.

- ! How many triangles are there in the 20^{th} rank? How did we get this value?

The expected answer is, x value represent the sequence number and the given value is written in the equation y = 2x + 1 and then value y which represent number of triangles is found.

y = 2. 20 +1

y= 41

- ! What kind of a way we use to find y value for any x value?

The expected answer is: y is dependent to the x, so given value of x is written on the equation, and then y value is found.

- ! What do we need to draw linear graph?

The expected answer is: we need points which are represented by ordered pairs (x, y).

It was expected to reach a result: to draw graph of a linear equation, points are needed. The coordinates of points are determined dependently to each other.

In the previous lectures, graphs of linear equations are drawn according to table. Now, for given linear equation, it is wanted from the students to make a table.

“Activitysheet4” is distributed to the students.

At the first question, it is asked to students to make a table which represents y = 3x linear equation. The possible answers are discussed. If any students cannot give an example, the below example can be given.

Example: A printing machine presses 3 books in an hour.

Time (min.) (x)	Number of books (y)
1	3
2	6
3	9
4	12
...	…
x	3x

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line though two points. Symbolic representation, tabular representation and graphical representation are seen on the screen together.

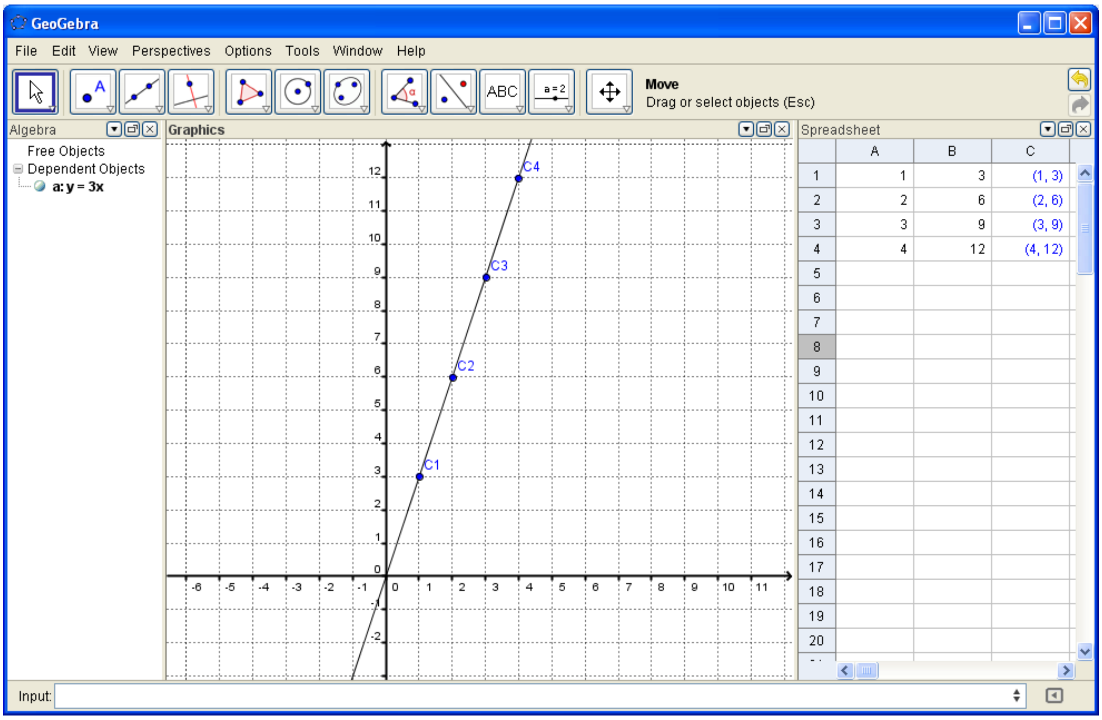


Figure: Symbolic representation, tabular representation and graphical representation of y=3x

At the second question, it is asked to students to make a table which represents y = 4x-3 linear equation. The possible answers are discussed. If any students cannot give an example, the below example can be given.

Example: A laboratory's temperature is measured as -3°C. and it decreases 4°C for each hour.

Time (hour) (x)	Temperature (°C) (y)
1	4.1 -3 =1
2	4.2 -3=5
3	4.3 -3=9
4	4.4-3=13
...	…
x	4x -3

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line through two points. Symbolic representation, tabular representation and graphical representation are seen on the screen together.

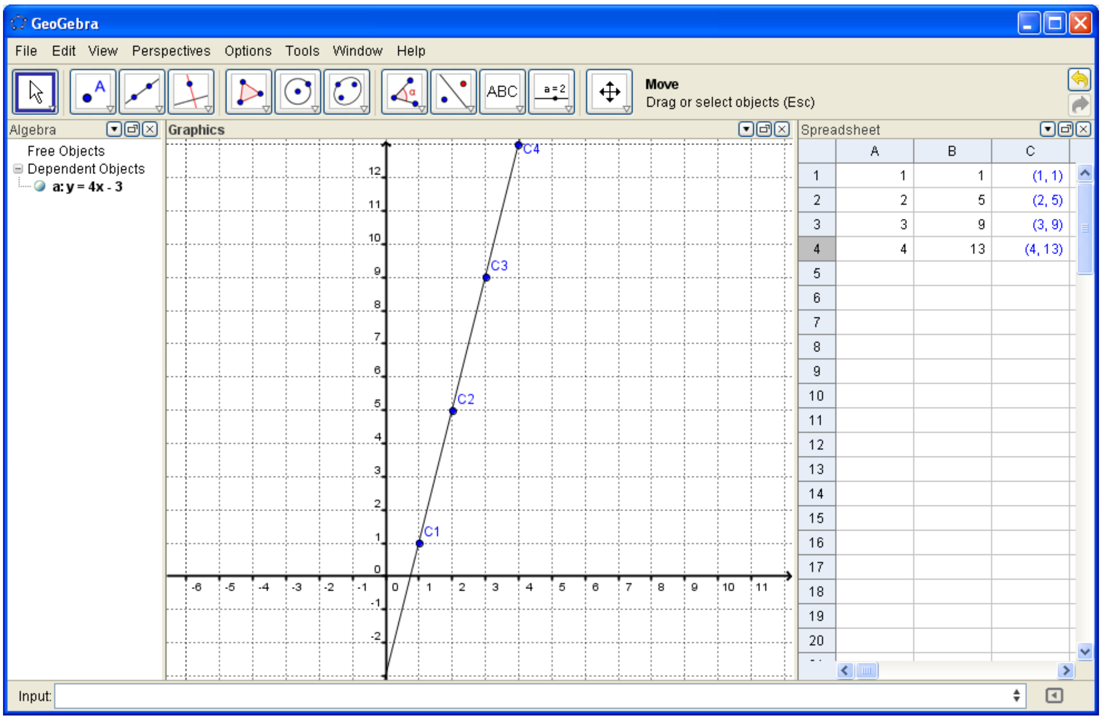


Figure: Symbolic representation, tabular representation and graphical representation of y=4x-3

At the third question, it is asked to students to make a table which represents y = 2 linear equation. The possible answers are discussed. If any students cannot give an example, the below example can be given.

Example: Ali is two years older than his little brother. The difference between their ages in terms of years.

Passing Time (year) (x)	Age difference (y)
1	2
2	2
3	2
4	2
...	...
x	2

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line through two points.

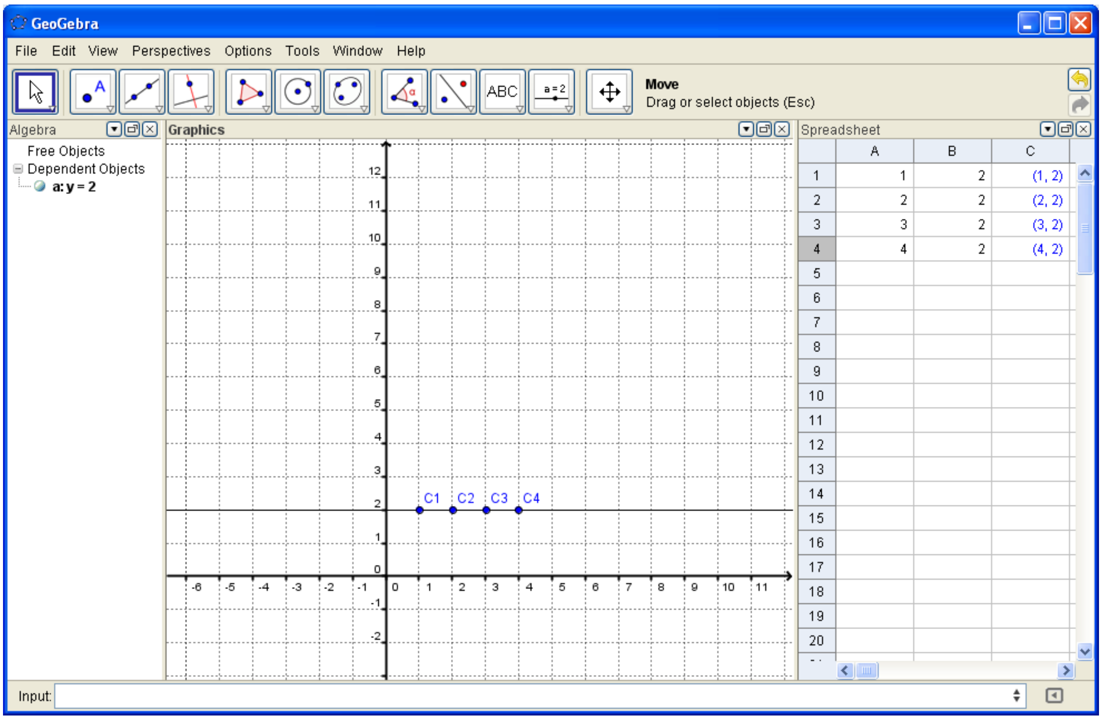


Figure: Symbolic representation, tabular representation and graphical representation of y=2

To sum up, it should be emphasized that y is dependent on the x values, so given value of x is written on the equation, and then y value is found. As a result, points, which are needed to draw a graph, can be found.

Part 2

Duration: 40 min.

Objectives:

- ✓ Transform representation of a linear equation from symbolic to graphical representation

In the first part, according to random value of x, y is found dependently. In the second part, according to y value, x will be found dependently. The lecture goes on with fourth question.

At the fourth question, it is asked to students to make a table which represents y = -3x linear equation. It is stressed that <u>any value</u> can be given to the y to find x. it is asked which values supply easy computation.

(x)	(y)
	-6
	-3
	3
	6
	9
x	-3x

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line through two points.

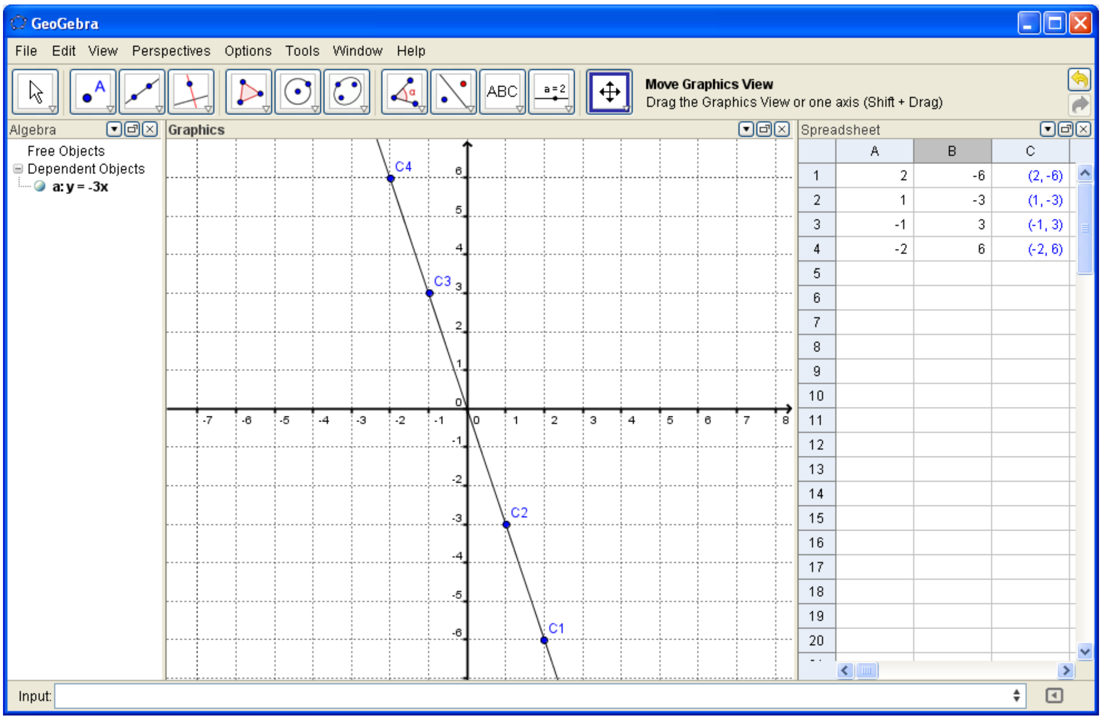


Figure: Symbolic representation, tabular representation and graphical representation of y=-3x

At the fifth question, it is asked to students to make a table which represents y = x-4 linear equation. The question, which values supply easy computation to find x, is discussed.

(x)	(y)
	1
	2
	3
	4
	5
x	x-4

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line through two points.

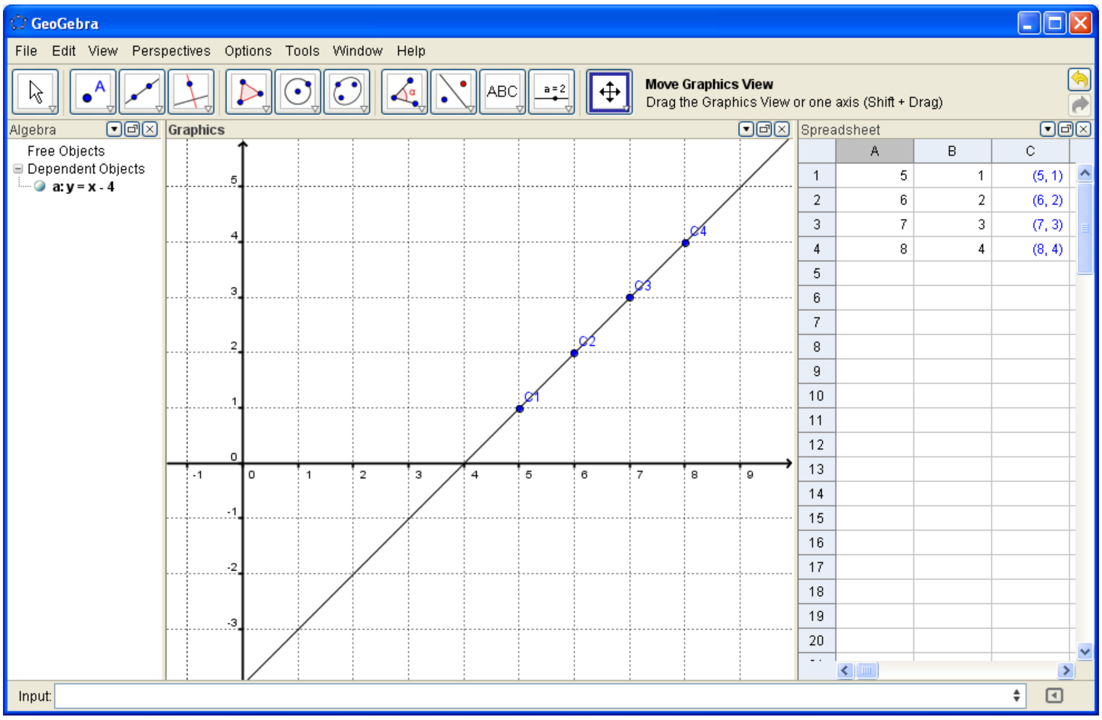


Figure: Symbolic representation, tabular representation and graphical representation of y=x-4

At the sixth question, it is asked to fill the table for the equation y = 2x-6. Students are to find x when y is equal to zero and then find y when x equal to zero.

x	y
0	
	0

A GeoGebra file is opened and the data on the table are written on the spreadsheet, and (x,y) ordered pairs are written on the right column of the each row. Then students connect the points using line through two points.

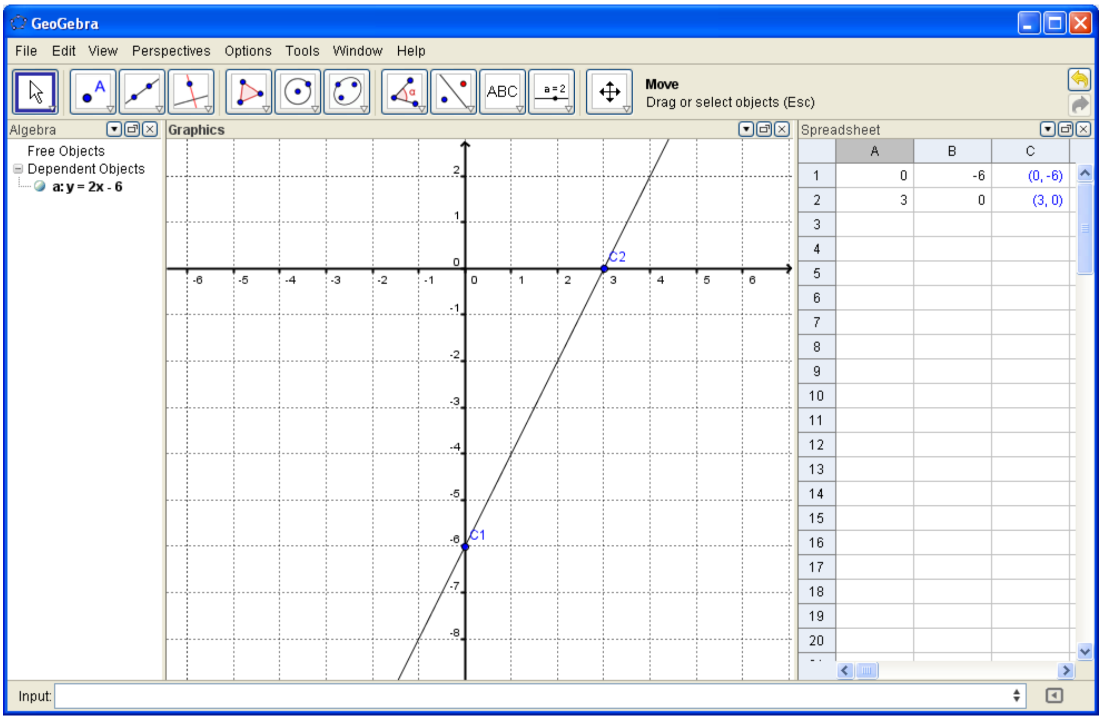


Figure: Symbolic representation, tabular representation and graphical representation of y=2x-6

When the results are discussed, the students are expected to realize finding points by giving zero to each unknown supplies easy computation; also the intercept points with axes can be found by this method.

Part 3:

Duration: 40 min.

Objectives:

- ✓ Explain the symbolic representation of a linear equation passing through the origin
- ✓ Explain the symbolic representation of a linear equation intercepting the axes.
- ✓ Find points on the graph of a linear equation

Students enter below equations into the input part of the GeoGebra.

y = 2x

y = -3x

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

y = 5x

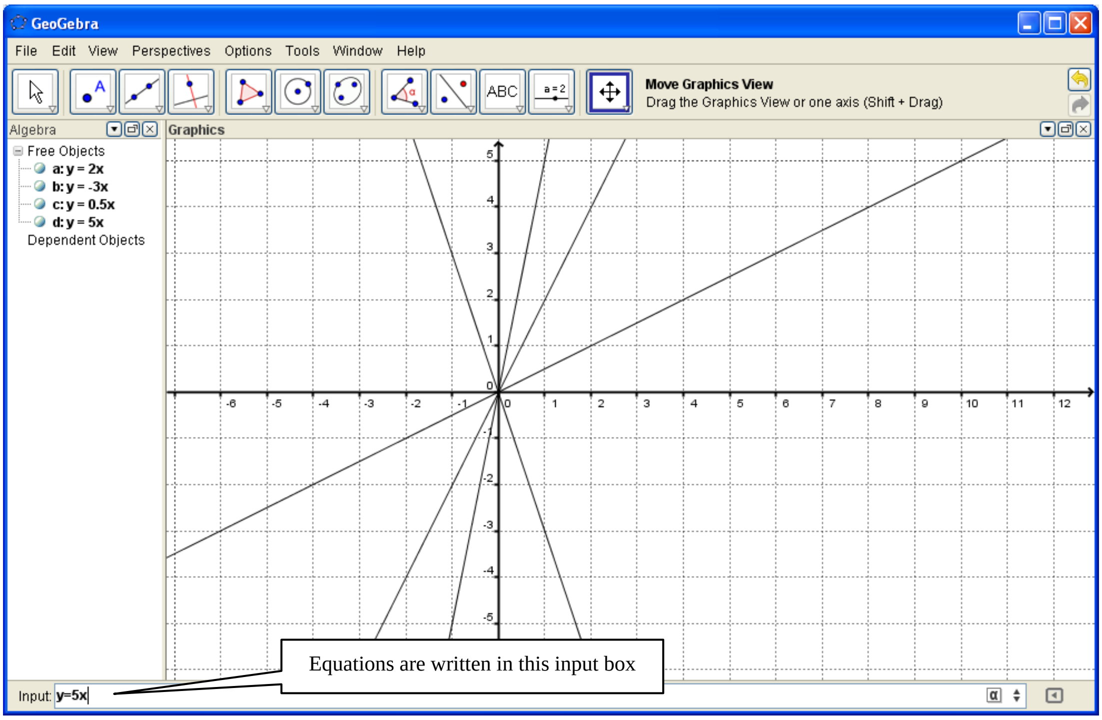


Figure: Symbolic representation and graphical representation of the linear equations passing through origin

Symbolic representations of the equations are shown on algebra view and graphical representations are shown on graphic view of GeoGebra. The representations are examined and it was expected that students discover the form of symbolic representation of the linear equations passing through origin as y = mx.

Students enter below equations into the input part of the GeoGebra.

$y = 2x+1$

$y = -3x + 2$

$$y = \frac{1}{2}x - 4$$

$y = x+5$

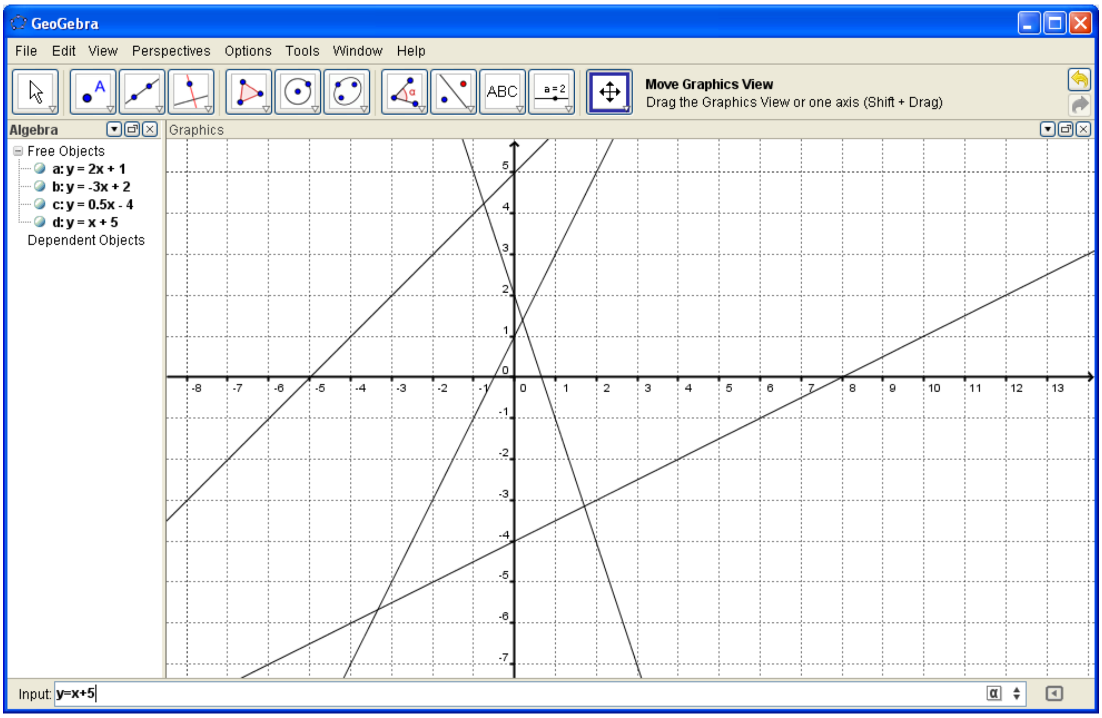


Figure: Symbolic representation and graphical representation of the linear equations intercepting the axes

Symbolic representations of the equations are shown on algebra view and graphical representations are shown on graphic view of GeoGebra. The representations are examined and it was expected that students discover the form of symbolic representation of the linear equations intercepting the axes as y = mx + n.

Students make practice with the “*kelimebulmaca*” GeoGebra file. “*Activitysheet5”* is distributed to students. In the word puzzle, there are hidden words which are written horizontally, vertically or cross. To find the hidden words, students should draw the graph of equation on the “*activitysheet6”*.

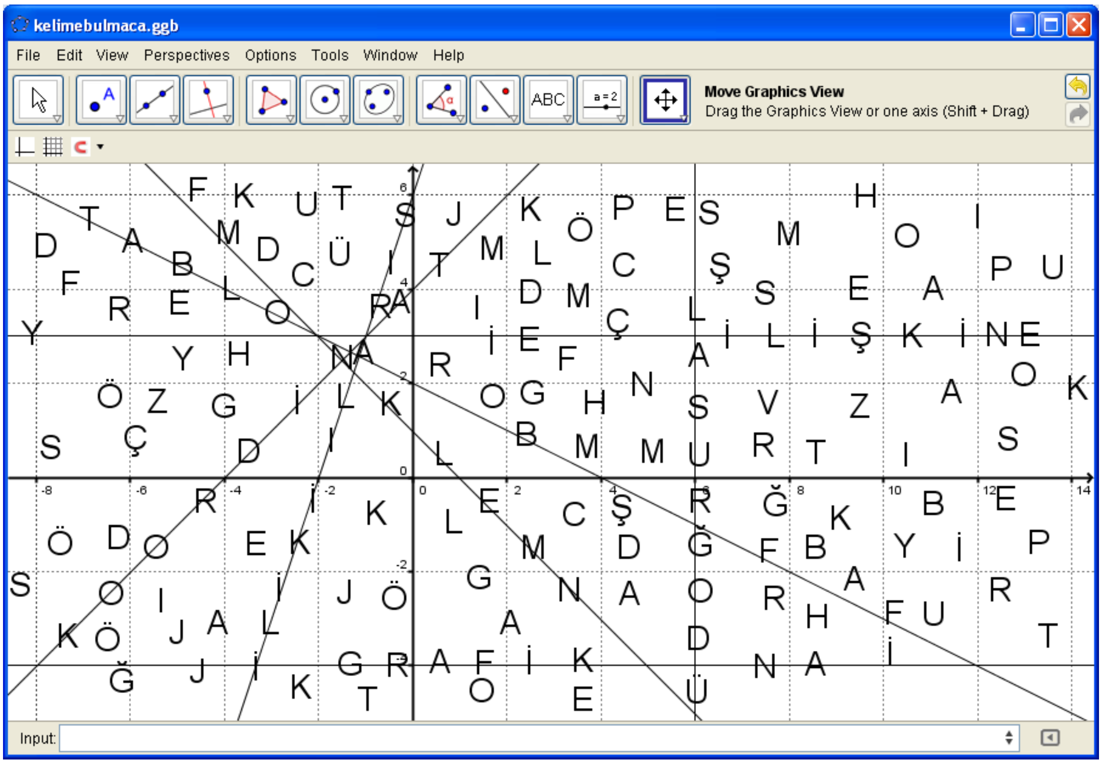


Figure: kelimebulmaca

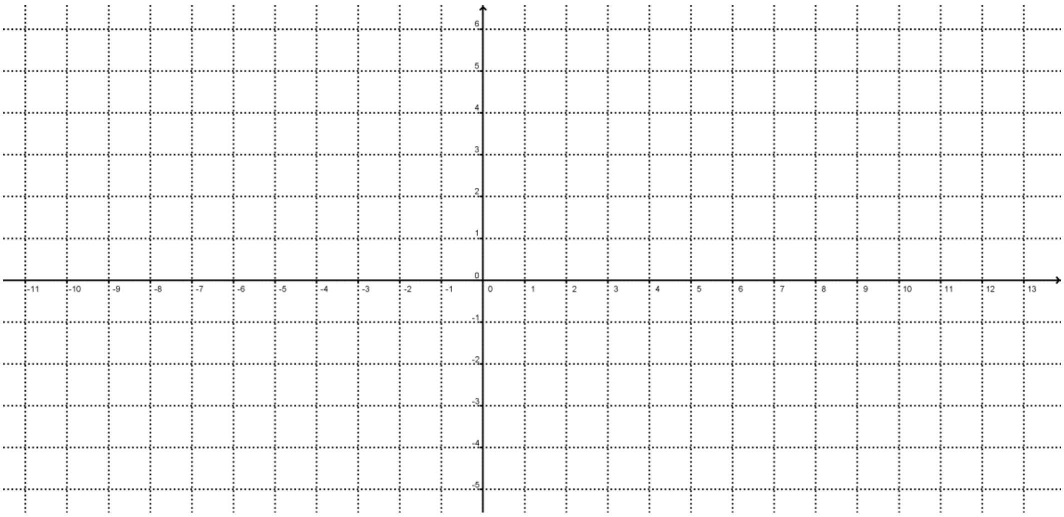
APPENDIX B. ACTIVITY SHEETS

ACTIVITY SHEET 1

Kartezyen koordinat sistemi 1. bölge

Verilen noktaları öncelikle "*koordinat 1. bölge*" GeoGebra dosyasında, daha sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

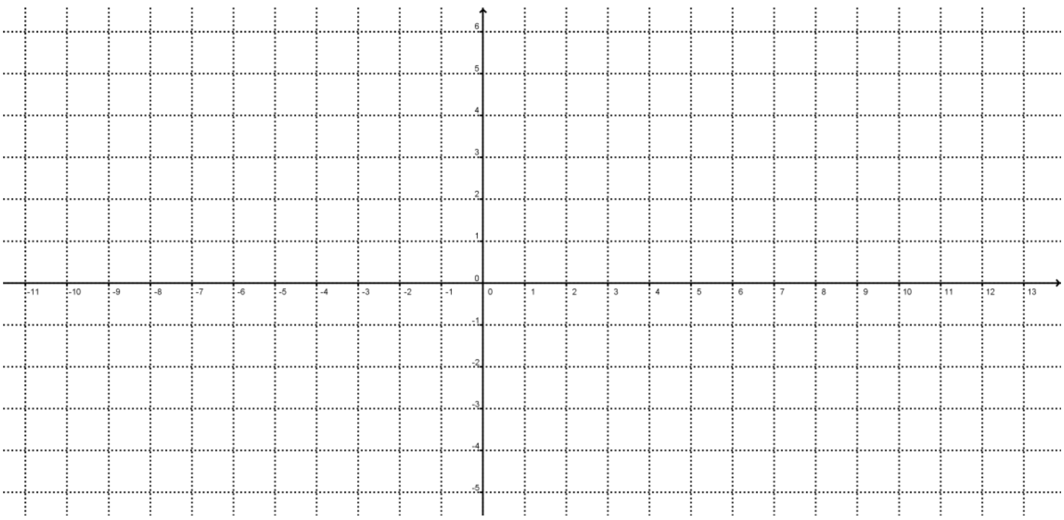
A(3,4) B(5,1) C(8,5) Ç(1,6) D(11,2)



Kartezyen koordinat sistemi 2. Bölge

Verilen noktaları öncelikle "*koordinat 2. bölge*" GeoGebra dosyasında, daha sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

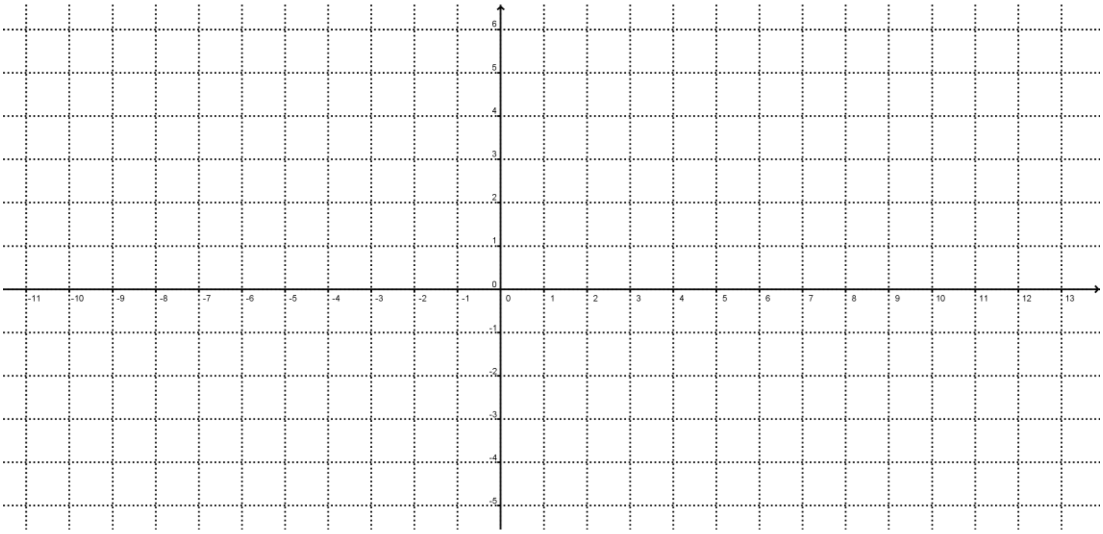
E (-3, 6) F(-1, 1) G(-9, 4) H(-5, 2) I(-6, 3)



Kartezyen koordinat sistemi 3. Bölge

Verilen noktaları öncelikle "*koordinat 3. bölge*" GeoGebra dosyasında, daha sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

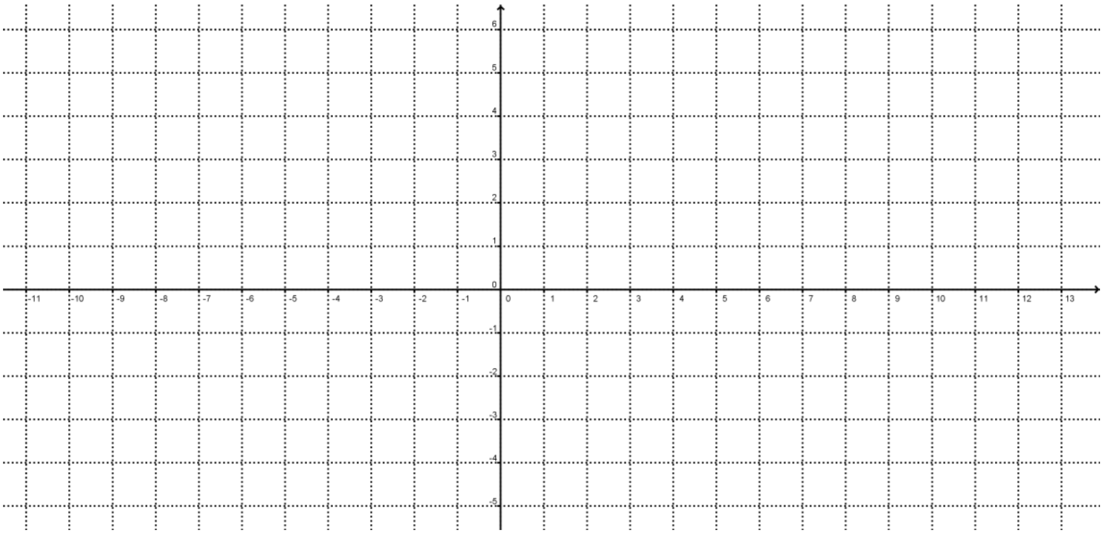
İ(-5,-3) **J(-8,-4)** **K(-1,-2)** **L(-2,-6)** **M(-3,-5)**



Kartezyen koordinat sistemi 4. Bölge

Verilen noktaları öncelikle "*koordinat 4. bölge*" GeoGebra dosyasında, daha sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

N(2, -4) **O(10, -6)** **Ö(1, -2)** **P(5, -3)** **R(4, -5)**



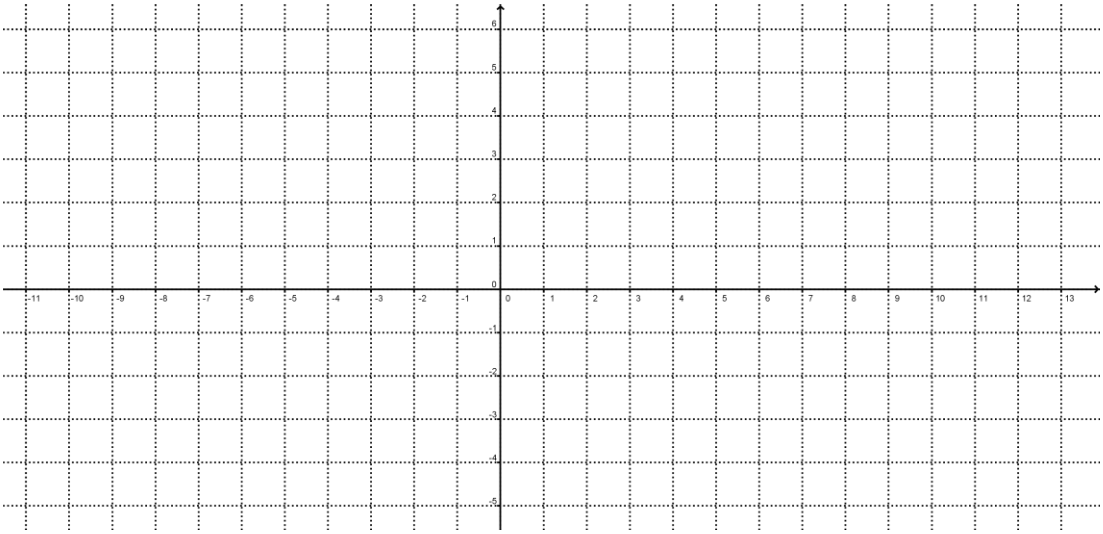
<u>Eksenler üzerindeki noktalar</u>

"*koordinat 1. bölge*" GeoGebra dosyasını açarak verilen noktaları önce GeoGebra dosyasında sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

S(4,0) **Ş(5,0)** **T(0,3)** **U(0, 6)**

"*koordinat 4. bölge*" GeoGebra dosyasını açarak verilen noktaları önce GeoGebra dosyasında sonra aşağıdaki Kartezyen koordinat sisteminde gösteriniz.

Ü(-8,0) **V(-2, 0)** **Y(0,-3)** **Z(0, -5)**



Aşağıdaki soruları yanıtlayınız.

1.bölgedeki noktaların koordinatlarının işaretleri nelerdir?

....

2.bölgedeki noktaların koordinatlarının işaretleri nelerdir?

....

3.bölgedeki noktaların koordinatlarının işaretleri nelerdir?

....

4.bölgedeki noktaların koordinatlarının işaretleri nelerdir?

....

ACTIVITY SHEET 2

Örnek 1:

Bir otomobil saatte 60 km yol gitmektedir. Buna göre geçen süre ve yol arasındaki ilişkiyi tablo yardımıyla bulunuz.

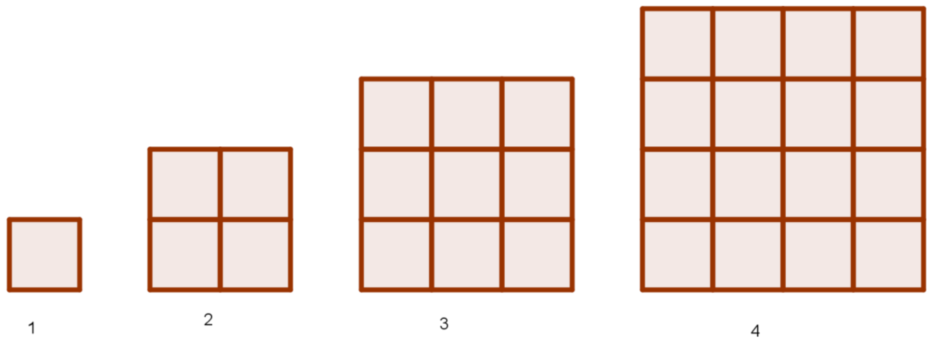
Cevap :

Süre (sa.)							
yol							

Alınan yolu geçen süre cinsinden yazabilir misiniz?

....

Örnek 2:



Aşağıdaki şekillerin sıra numarası ile kare sayıları arasındaki ilişkiyi tablo yardımıyla bulunuz.

Sıra no						
Kare sayısı						

Kare sayısını sıra numarası cinsinden yazabilir misiniz?

....

Örnek 3:

Taksi ile yapılan yolculukların ücreti taksimetre ile belirlenir. Ankara'da taksimetre 130 Kr. İle açılır ve her kilometrede 130 Kr. artar. Açılış ücretini de göz önüne alarak gidilen yol ile ücret arasındaki ilişkiyi tablo yardımıyla bulunuz.

Yol (km.)	Ücret (Kr.)

Ödenen ücreti gidilen yol cinsinden yazabilir misiniz?

....

Örnek 4:

Bir garson işe başladığı kafede birinci gün 10 TL., ikinci gün 7 TL., üçüncü gün 16 TL, ve dördüncü gün 15 TL. bahşiş almıştır. Bu garsonun çalıştığı gün sayısıyla aldığı bahşiş arasında bir ilişki olup olmadığını tablo yardımıyla bulunuz.

Gün	Bahşiş (TL.)

Alınan bahşişi gün cinsinden yazabilir misiniz?

....

Örnek 5:

Bir telefon şirketi aylık 50 TL.'ye sınırsız konuşma imkanı veren bir kampanya yapmıştır. Buna göre 1 ay içerisinde konuşulan dakika ile ödenen ücret arasında ilişki olup olmadığını tablo yardımıyla inceleyiniz.

Konuşulan süre (dk.)	Aylık ücret (TL.)

Aylık ödenen ücreti konuşma süresi cinsinden yazabilir miyiz?

....

ACTIVITY SHEET 3

Bölüm 1

Örnek 1:

1 kilogram elmanın fiyatı 2 TL ise, diğer değerler için tabloyu doldurunuz.

Ağırlık (Kg.)	Ücret (TL.)
2	
3	
4	
5	

Elde ettiğiniz tabloyu bir GeoGebra dosyası açarak hesap çizelgesine yazınız. Elmanın ağırlığını x, ücretini y olarak düşünerek her bir satırın sağındaki hücreye (x,y) sıralı ikililerini yazınız.

Ne gözlemlediniz? Sizce ilişki doğrusal bir ilişki mi?

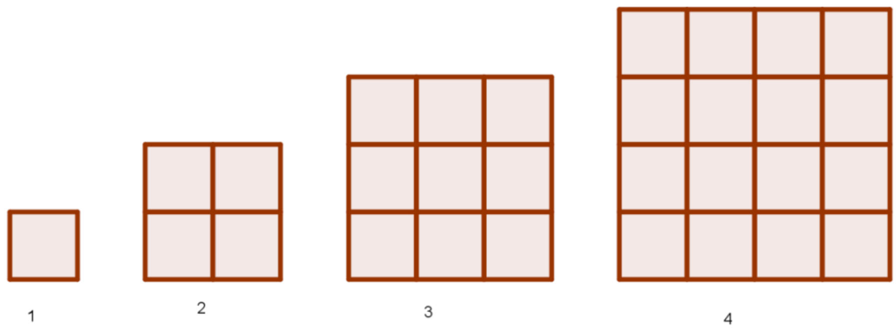
…………………………………………………………………

Elmanın ağırlığı x, ücreti ise y olarak düşünülürse; ücretin, ağırlık cinsinden değeri ne olur?

………………………………………………………………………………………

Örnek 2:

Aşağıdaki tabloyu sıra numarasını ve o sıradaki kare sayısını dikkate alarak doldurunuz.



Sıra numarası	Kare sayısı
1	
2	
3	
4	

Elde ettiğiniz tabloyu bir geogebra dosyası açarak hesap çizelgesine yazınız. Sıra numarasını x, kare sayısını y olarak düşünerek her bir satırın sağındaki hücreye (x,y) sıralı ikililerini yazınız.

Ne gözlemlediniz? Sizce ilişki doğrusal bir ilişki mi?

…………………………………………………………………

Sıra numarası x, kare sayısı y olarak düşünülürse; kare sayısının sıra numarası cinsinden değeri ne olur?

....

<u>Örnek 3:</u>

5 cm.'lik yayın ucuna farklı kütlelerde ağırlık bağlanıyor. Her 1 kg.lık kütlenin bağlanmasıyla yay 2 cm. uzuyor. Buna göre yayın uzunluğu ile kütle arasındaki ilişkiyi tablo yardımıyla bulunuz.

Kütle (kg.)	Yayın uzunluğu (cm.)
1	
2	
3	
4	

Elde ettiğiniz tabloyu bir geogebra dosyası açarak hesap çizelgesine yazınız. Kütlenin ağırlığını x, yayın uzunluğunu y olarak düşünerek her bir satırın sağındaki hücreye (x,y) sıralı ikililerini yazınız.

Ne gözlemlediniz? Sizce ilişki doğrusal bir ilişki mi?

…………………………………………………………………

Kütlenin ağırlığı x, yayın uzunluğu y olarak düşünülürse; yayın uzunluğunun kütlenin ağırlığı cinsinden değeri ne olur?

....

Örnek 4:

Bir otobüs, güzergahını 4 L. benzin ile tamamlamaktadır. Yolcu sayısı ile harcanan benzin arasındaki ilişkiyi tablo yardımıyla bulunuz.

Yolcu sayısı	Harcanan benzin (L.)
1	
2	
3	
4	

Elde ettiğiniz tabloyu bir geogebra dosyası açarak hesap çizelgesine yazınız. Yolcu sayısını x, harcanan benzini y olarak düşünerek her bir satırın sağındaki hücreye (x,y) sıralı ikililerini yazınız.

Ne gözlemlediniz? Sizce ilişki doğrusal bir ilişki mi?

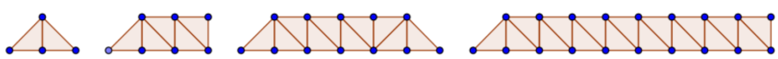
…………………………………………………………………

Yolcu sayısını x, harcanan benzini y olarak düşünersek; harcanan benzinin yolcu sayısı cinsinden değeri ne olur?

....

Örnek 5:

Aşağıdaki tabloyu sıra numarasını ve o sıradaki üçgen sayısını dikkate alarak doldurunuz



1 2 3 4 … n

Sıra numarası	Üçgen sayısı
1	
2	
3	
4	

Elde ettiğiniz tabloyu bir GeoGebra dosyası açarak hesap çizelgesine yazınız. Sıra numarasını x, üçgen sayısını y olarak düşünerek her bir satırın sağındaki hücreye (x,y) sıralı ikililerini yazınız.

Ne gözlemlediniz? Sizce ilişki doğrusal bir ilişki mi?

…………………………………………………………………

Sıra numarasını x, üçgen sayısını y olarak düşünürsek; üçgen sayısının sıra numarası cinsinden değeri ne olur?

....

<u>Bölüm 2</u>

Tabloyu doldurunuz.

Doğrusal ilişkiler	Doğrusal olmayan ilişkiler

Doğrusal ilişki olması için ilişkiyi belirten denklem ………………………… olarak genellenebilir.

Bölüm 3

Aşağıdaki denklemlerden doğrusal olanlarını X işareti koyarak işaretleyiniz.

.........$y=4x$	.... $y=x^3-5$	.........$x^2+3y=6$	.... $4x-6y-16=0$
.........$y=5$	.... $y=5x+4$	.........$6x-5=10$	.... $2x^2-3y^2=0$
.........$x=2$	.... $y=\frac{2}{3}x+1$	.........$2x+3y+9=0$	.... $3x+2y=14$

ACTIVITY SHEET 4

Örnek 1:

Aşağıdaki tabloyu y= 3x ilişkisini temsil edecek şekilde doldurunuz.

…………… (x)	…………… (y)
...	...
x	3x

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz.

Örnek 2:

Aşağıdaki tabloyu y= 4x – 3 ilişkisini temsil edecek şekilde doldurunuz

…………… (x)	…………… (y)
...	...
x	4x – 3

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz.

Örnek 3:

Aşağıdaki tabloyu y= 2 ilişkisini temsil edecek şekilde doldurunuz

…………… (x)	…………… (y)
...	...
x	2

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz.

y değerlerini nasıl elde ettiniz? Açıklayınız.

………………………………………………………………………………………

Örnek 4:

y=-3x ilişkisini temsil eden denklemin tablosunu öncelikli olarak y ye değer vererek doldurunuz. İşlem kolaylığı sağlaması için hangi değerler verilebilir?

…………… (x)	…………… (y)
...	...
x	-3x

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz

Örnek 5:

y=x-4 ilişkisini temsil eden denklemin tablosunu öncelikli olarak y ye değer vererek doldurunuz. İşlem kolaylığı sağlaması için hangi değerler verilebilir?

…………… (x)	……………. (y)
...	...
x	x-4

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz

Örnek6:

y= 2x -6 denklemin tablosunu y'nin 0 değeri için x'in değerini bularak ve x'in 0 değeri için y'nin değerini bularak doldurunuz.

x	y
0	
	0

Oluşan tabloyu GeoGebra dosyasındaki hesap çizelgesine girerek noktaları belirleyiniz.

Oluşan noktaları birleştiriniz.

Oluşan doğru grafiğinde ne gözlemlediniz?

....

ACTIVITY SHEET 5

<u>Kelime Bulmaca</u>

"*Kelimebulmaca*" GeoGebra dosyasını açınız. Gizlenmiş olan kelimeleri bulabilmek için aşağıdaki denklemlerin grafiklerini çizmeniz gerekmektedir. Çizilen grafikler size gizlenmiş olan kelimeyi gösterecektir. Denklemlerin grafiğini çizdikten sonra bulduğunuz kelimeyi denklemin karşısına yazınız.

Başarılar.

$y = 3$ ....

$y = 3x + 6$ ....

$y = -4$ ....

$x + y = 1$ ....

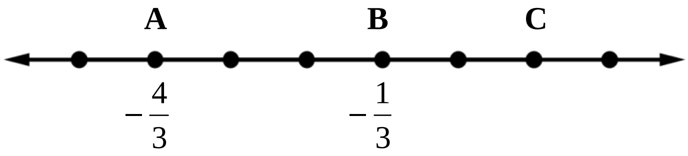
$x =6$ ....

$y = x + 4$ ....

$x + 2y – 4 = 0$ ....

APPENDIX C. READINESS TEST

1)



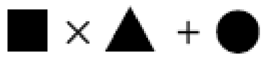
Verilen sayı doğrusunda işaretlenen ardışık noktalar arası aynı uzunluktadır. A ve B noktaları $-\frac{4}{3}$ ve $-\frac{1}{3}$ sayıları ile eşleştiğine göre, C noktası aşağıdakilerden hangisi ile eşlenir?

a) 0 b) $\frac{1}{3}$ c)1 d) $\frac{5}{3}$

2) $\dfrac{1-\frac{1}{5}}{2}$ işleminin sonucu hangisidir?

a) $\frac{2}{5}$ b) $\frac{1}{2}$ c) $\frac{8}{5}$ d) $\frac{5}{2}$

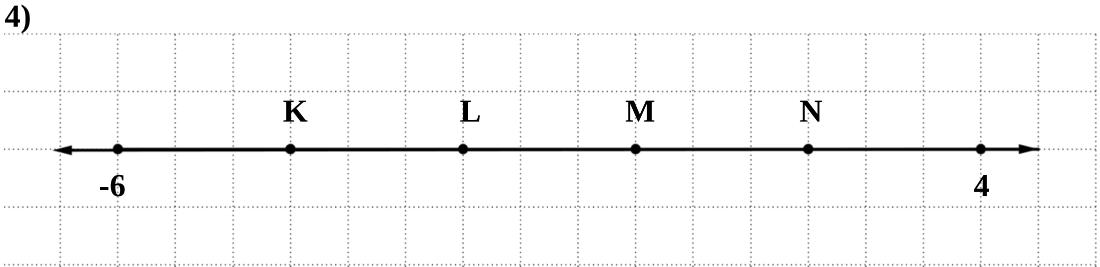
3)



-8, +3, -2 sayıları yukarıdaki semboller yerine hangisindeki gibi yerleştirilirse elde edilen işlemin sonucu en büyük olur?

a)	-8	+3	-2
b)	+3	-8	-2
c)	-2	+3	-8
d)	-8	-2	+3

4)



Verilen sayı doğrusunda aşağıdakilerden hangisi -2 tam sayısını gösterir?

a) K b) N c) L d) M

5) 103 sayısı, kuralı verilen aşağıdaki sayı örüntülerinden hangisinin herhangi bir adımında **<u>yer almaz</u>?**

a) 2n + 1 b) 2n + 2 c) n + 2 d) n + 1

6) (-7) + 5 + (-3) işlemi yapılırken aşağıdakilerden hangisinde hata yapılmamıştır?

a) (-7)+5+(-3) = (-7)+(-2) = -9
b) (-7)+5+(-3) = (-12)+(-3) = -9
c) (-7)+5+(-3) = (-7)+(-2) = -5
d) (-7)+5+(-3) = (-2)+(-3) = -5

7) Aşağıdakilerden hangisi $\frac{1}{2}$ ile toplandığında elde edilen sayı -1 ile 0 arasında yer alır?

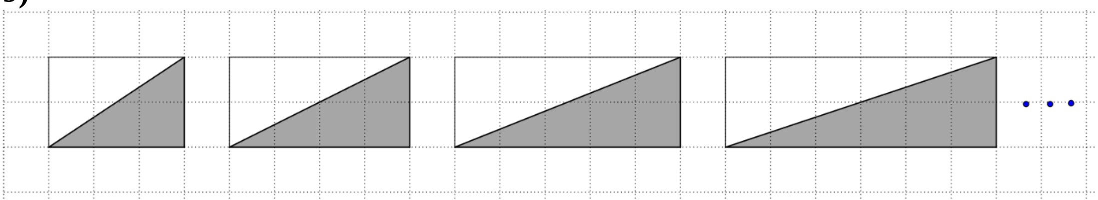
a) $-\frac{1}{4}$ b) $-\frac{1}{3}$ c) -1 d) 1

8) Bir kuruyemişçi aşağıda miktarları verilen kuruyemişlerin tümünü karıştırıyor. Bu karışımı eşit miktarda 4 paket yaptıktan sonra satışa sunuyor. Her bir paket kaç kilogramdır?
Karışımdaki kuruyemiş miktarları:

Fındık: $\frac{3}{10}kg.$ fıstık: $\frac{5}{6}kg.$ çekirdek: $\frac{2}{5}kg.$ leblebi: $\frac{7}{15}kg.$

a) $\frac{1}{4}$ b) $\frac{1}{2}$ c) 1 d) 2

9)

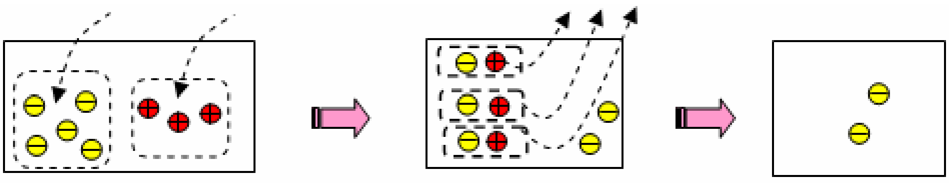


1. şekil **2. Şekil** **3. Şekil** **4. Şekil**

Verilen örüntü aynı kurala göre devam ettirilirse, örüntünün 28. şeklindeki boyalı bölgenin alanı kaç birimkare olur?

a) 26 b) 28 c) 30 d) 31

10)



Yukarıda sayma pulları ile modellenen işlemin matematiksel sembollerle gösterimi aşağıdakilerden hangisidir?

a) (+5) - (+3)= (+2)
b) (-5) + (+3)=(-2)
c) (+5)+ (-3) =(+2)
d) (+3) - (+5) = (-2)

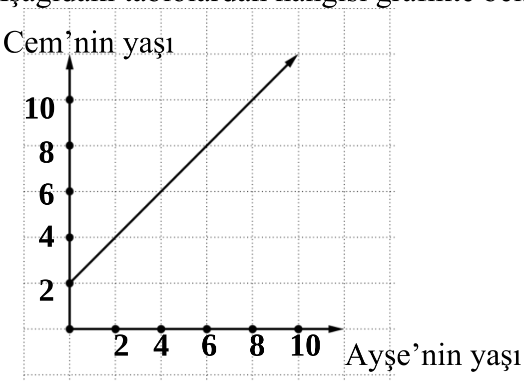
11) [-8x(5+(-9))] işleminin sonucu aşağıdakilerden hangisidir?

a) -40 b) -32 c) +32 d) 40

12) 2x + 6 = 20 denkleminin çözüm kümesi aşağıdakilerden hangisidir?
a) -7 b) 7 c) 13 d) 20

13) 3x + y -2 =0 denkleminde x'in -2 değeri için y kaçtır?
a) -4 b) 2 c) 4 d) 8

14) Aşağıdaki tablolardan hangisi grafikte belirtilen ilişkiyi temsil etmektedir?



a)

Cem'in yaşı	Ayşe'nin yaşı
2	2
4	4
6	6
8	8

b)

Cem'in yaşı	Ayşe'nin yaşı
0	2
2	4
4	6
6	8

c)

Cem'in yaşı	Ayşe'nin yaşı
2	0
4	2
6	4
8	6

d)

Cem'in yaşı	Ayşe'nin yaşı
0	2
4	6
6	8
8	10

15)

x	y
3	10
4	12
5	14
6	16

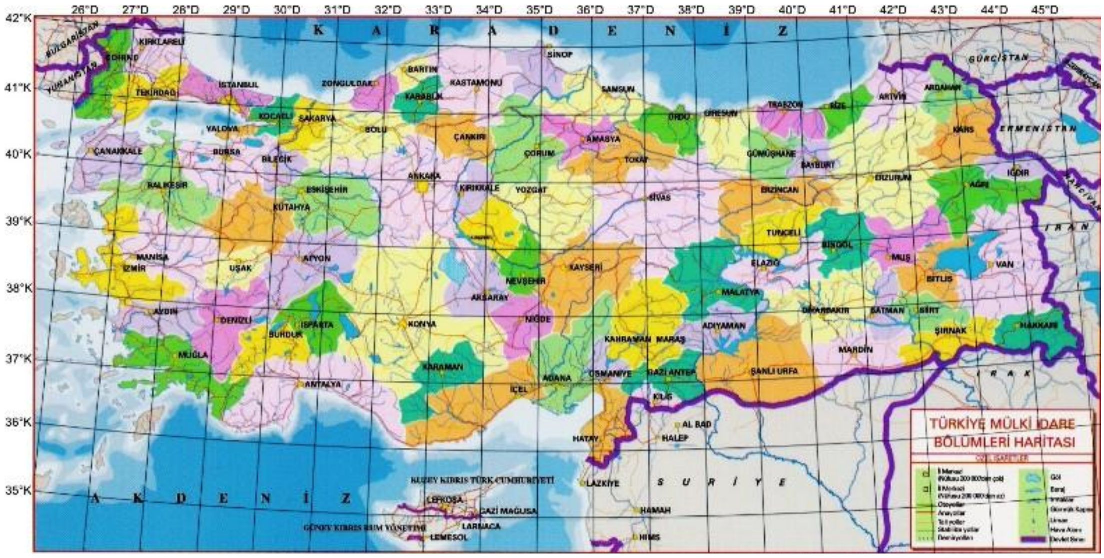
Aşağıdaki doğrusal denklemlerden hangisi, yandaki tabloda verilen x ve y değerleri arasındaki ilişkiyi açıklar?

a) y= 3x + 1 b) y= x + 7 c) y= 3x – 2 d) y= 2x + 4

APPENDIX D. MATHEMATICS ACHIEVEMENT TESTS

MATHEMATICS ACHIEVEMENT TEST 1

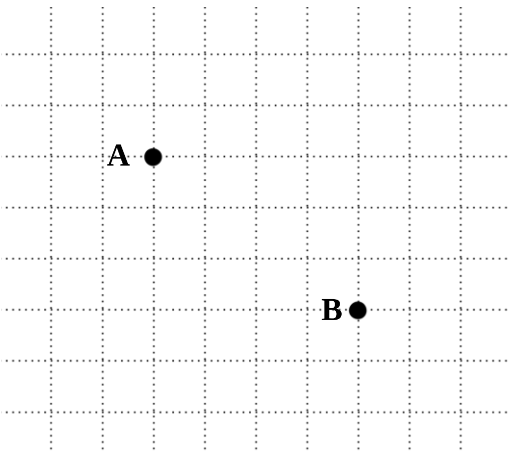
1)



Yukarıdaki Türkiye haritasında Türkiye’den geçen enlemler ve boylamlar gösterilmiştir. Ankara ilinin konumu yaklaşık olarak (40, 33) sıralı ikilisi olarak ifade edildiğine göre İstanbul ilinin konumu aşağıdaki sıralı ikililerden hangisi ile ifade edilebilir?

a)(29,41) b) (36, 42) c) (41, 29) d) (42, 33)

2)



A noktasının koordinatları (-1,2) ise B noktasının koordinatları nedir?

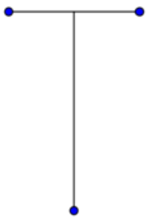
a) (3,-1) b) (2,-1) c) (6,-4) d) (-1, 3)

3) Aşağıdaki adımlar izlendiğinde koordinat düzleminde hangi harf oluşur?

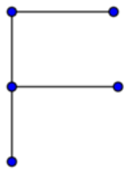
1. adım: Uç noktaları A(3, 1) ve B(3, -1) olan doğru parçasını çiziniz.

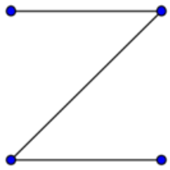
2. adım: C(4, 3) noktasını A noktası ile birleştiriniz.

3. adım: D(2, 3) noktasını A noktası ile birleştiriniz.

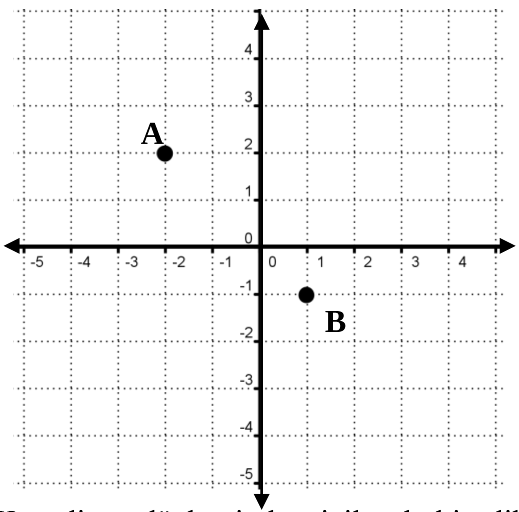
a) 

b) 

c) 

d) 

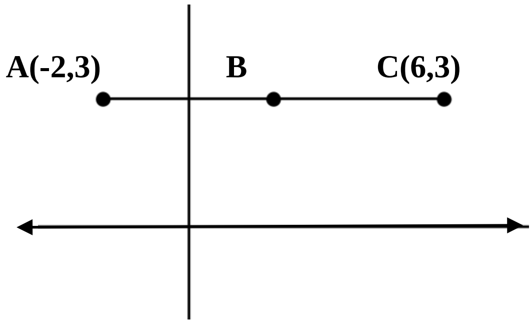
4)



Koordinat düzleminde çizilecek bir dik üçgenin köşe noktalarından ikisi şekilde işaretlenmiştir. Bu dik üçgenin üçüncü köşesinin koordinatları aşağıdakilerden hangisi olabilir?

a) (-1, 1) b) (-1,-2) c) (1, 1) d) (1, 2)

5)

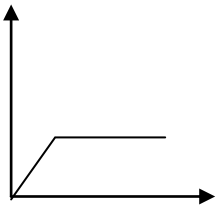


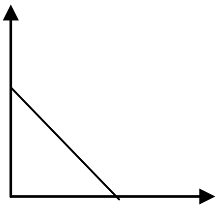
Grafikte B noktası uç noktasın koordinatları verilen AC doğru parçasının orta noktasıdır. Aşağıdakilerden hangisi B noktasının koordinatlarıdır?

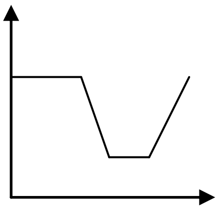
a) (2, 3) b) (3,0) c) (3,3) d) (4,-3)

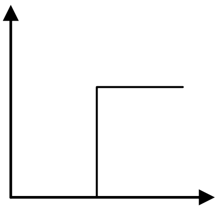
MATHEMATICS ACHIEVEMENT TEST 2

1) Aşağıdaki grafiklerden hangisi doğrusal bir ilişkiyi temsil eder?

a) 

b) 

c) 

d) 

x	y
3	10
4	12
5	14
6	16

2) Aşağıdaki doğrusal denklemlerden hangisi, yanda verilen tablodaki x ve y değerleri arasındaki ilişkiyi açıklar?

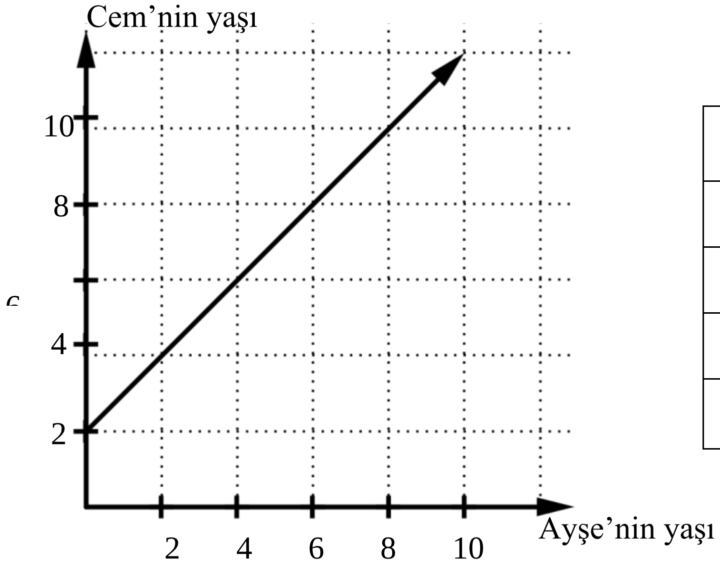
a) y= 3x + 1

b) y= x + 7

c) y= 3x – 2

d) y= 2x + 4

3) Aşağıda grafiği verilen ilişkinin tablosunu oluşturunuz.



Cem’in yaşı	Ayşe’nin yaşı

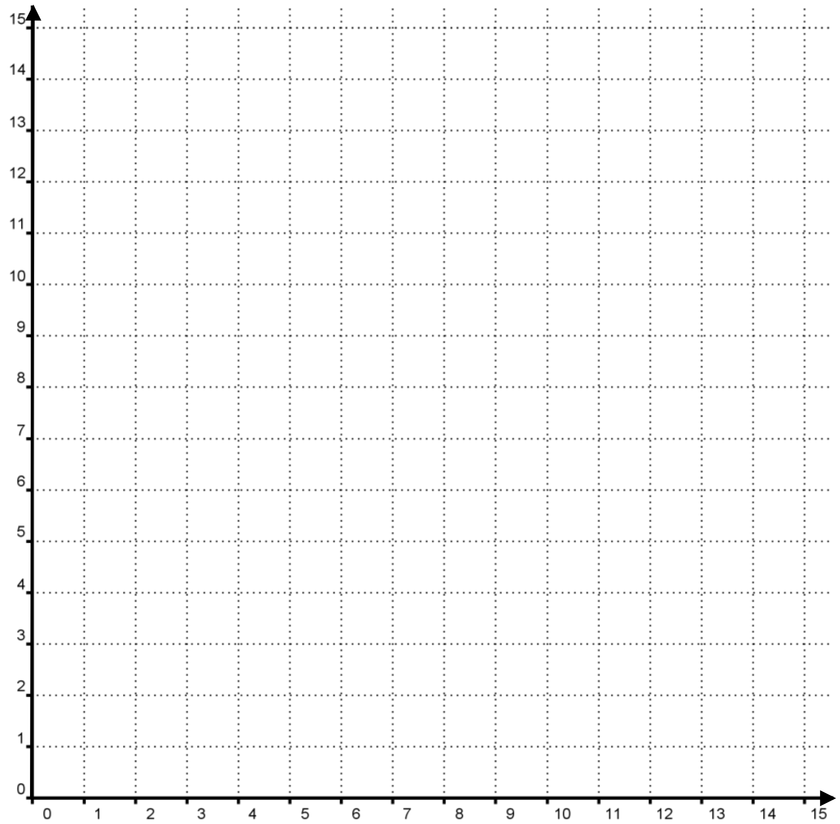
4) Aşağıdaki denklemlerden hangisi doğrusal bir ilişkiyi temsil etmektedir?

a) $2x^2+y=3$ b) $y= x^2$ c) $x+4y +12 = 0$ d) $2x + 3y^2= 2$

5)

p	0	1	2	3	4
r	2	5	8	11	14

p, x-ekseninde r de y-ekseninde yer almak üzere p ve r arasındaki ilişkinin grafiğini çiziniz.

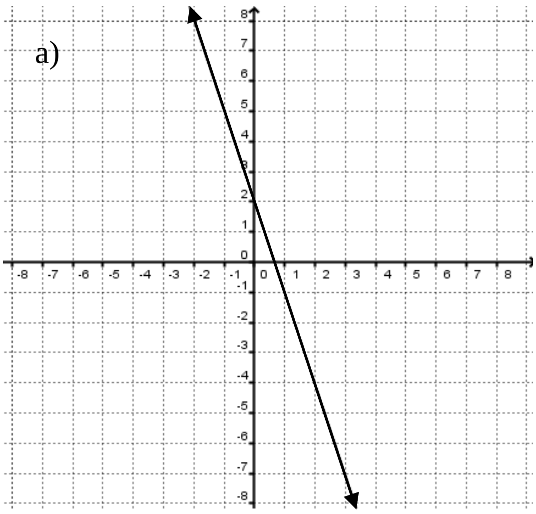


MATHEMATICS ACHIEVEMENT TEST 3

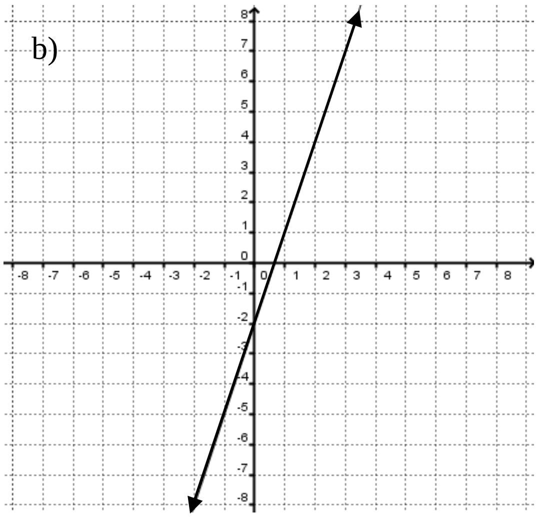
1) Yandaki tabloda ifade edilen denklemin grafiği aşağıdaki seçeneklerden hangisidir?

x	-2	-1	0	1	2
y	8	5	2	-1	-4

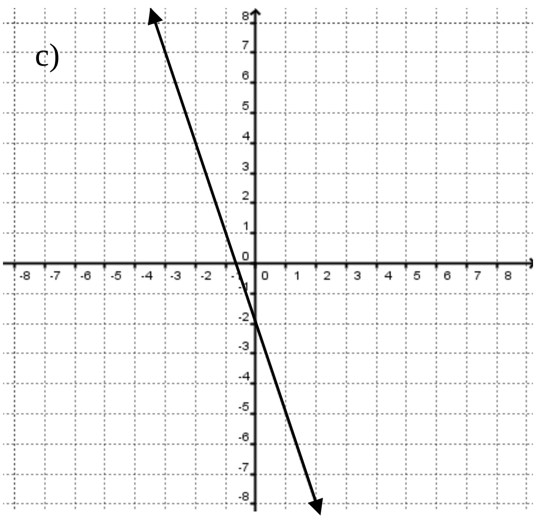
a)



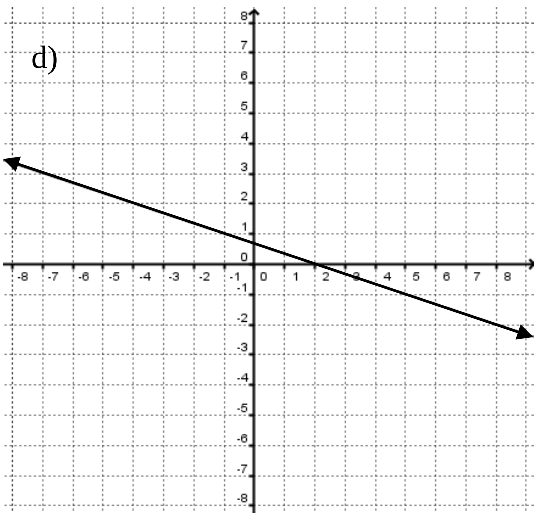
b)



c)



d)



2) Aşağıdaki doğru denklemlerinden hangisinin grafiği orijinden geçer?

a) y= 2x + 2

b) 4 – 2x =8

c) y= 3x

d) y = 4

3) x+2 = y doğrusunun üzerinde olan A(0,?) noktasının ordinatı kaçtır?

a) 0 b) 2 c) -2 d) 1

4) 4x - 3y +12 =0 doğrusu apsisi A noktasında, ordinatı B noktasında kesmektedir. Buna göre A ve B noktasının koordinatları nedir?

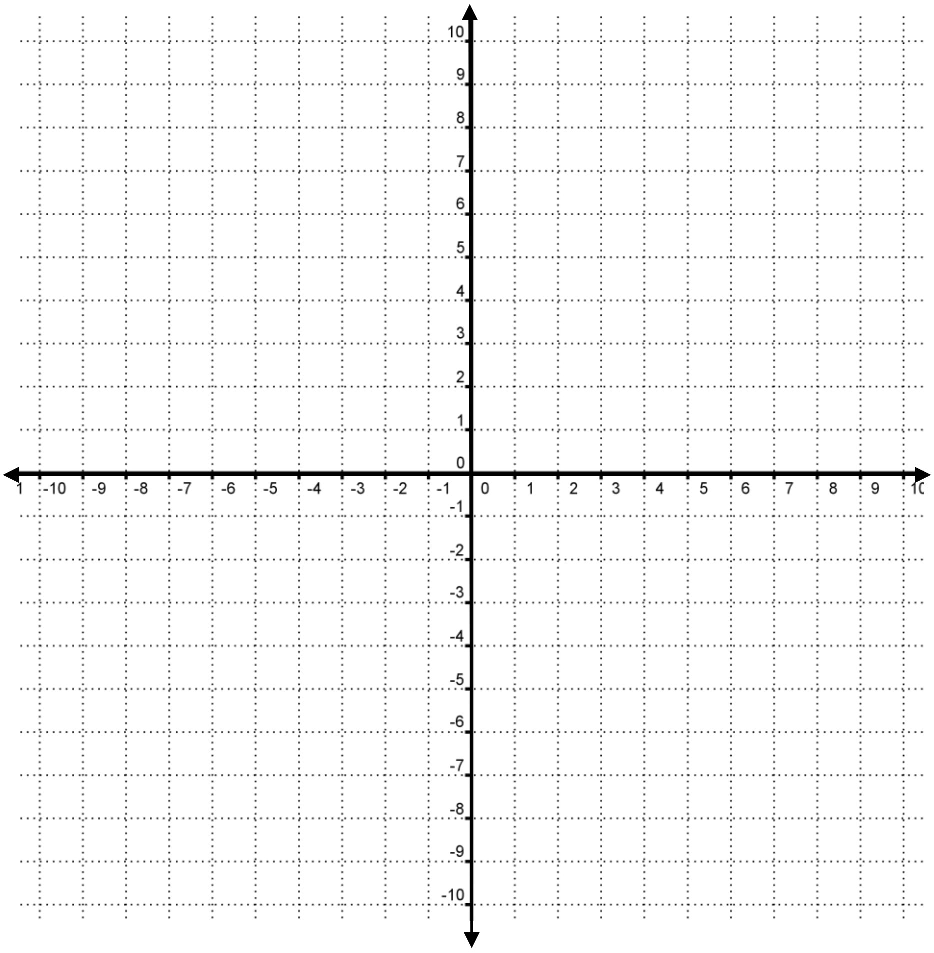
a) A(-3,0) ,B (0, 4)

b) A(4,0), B(0,-3)

c) A(4,-3), B(-3,4)

d) A(0,-3), B(4,0)

5) 3x+4y = 24 doğrusunun grafiğini çiziniz.



APPENDIX E.TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	
Sosyal Bilimler Enstitüsü	X
Uygulamalı Matematik Enstitüsü	
Enformatik Enstitüsü	
Deniz Bilimleri Enstitüsü	

YAZARIN

Soyadı : Doktoroğlu
Adı : Rezzan
Bölümü : İlköğretim Fen ve Matematik Eğitimi

TEZİN ADI : The Effects of Teaching Linear Equations With Dynamic Mathematics Software on Seventh Grade Students' Achievement

TEZİN TÜRÜ : Yüksek Lisans [X] Doktora [ ]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [X]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. [ ]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: