THE EFFECTS OF MATHEMATICS INSTRUCTION SUPPORTED BY DYNAMIC GEOMETRY ACTIVITIES ON SEVENTH GRADE STUDENTS' ACHIEVEMENT IN AREA OF QUADRILATERALS

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ABSTRACT

THE EFFECTS OF MATHEMATICS INSTRUCTION SUPPORTED BY DYNAMIC GEOMETRY ACTIVITIES ON SEVENTH GRADE STUDENTS' ACHIEVEMENT IN AREA OF QUADRILATERALS

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The aim of this study was to investigate the effects of mathematics instruction supported by dynamics geometry activities on students' achievement in area of quadrilaterals and students' achievements according to their van Hiele geometric thinking levels. The study was conducted in a public elementary school in Kırşehir in 2012 – 2013 spring semester and lasted two weeks. The participants in the study were 76 seventh grade students. The study was examined through nonrandomized control group pretest-posttest research design. In order to gather data, Readiness Test for Area and Perimeter Concepts (RTAP), Area of Quadrilaterals Achievement Test (AQAT) and van Hiele Geometric Thinking Level Test (VHLT) were used. A two-way analysis of variance (ANOVA) procedure was employed to answer research questions. The result of the study indicated that there was a significant interaction between the effects of method of teaching and van Hiele geometric thinking level on scores of AQAT. In addition, mathematics instruction supported by dynamic geometry activities had significant effects on seventh grade students' achievement on area of quadrilaterals topic. The results also revealed that students in experimental group were significantly more successful in AQAT than students in comparison group when the students were in second level of van Hiele geometric thinking.

Keywords: Mathematics Education, Dynamic Geometry Software, GeoGebra, van Hiele Geometric Thinking Levels, Area of Quadrilaterals.

ÖZ

DİNAMİK GEOMETRİ ETKİNLİKLERİ İLE DESTEKLENEN MATEMATİK ÖĞRETİMİNİN YEDİNCİ SINIF ÖĞRENCİLERİNİN DÖRTGENLERDE ALAN KONUSUNDAKİ BAŞARILARINA ETKİSİ

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Bu çalışma, dinamik geometri etkinlikleri ile desteklenen matematik öğretiminin yedinci sınıf öğrencilerinin dörtgenlerde alan konusundaki başarılarına etkisini ve bu öğrenci başarılarının van Hiele düzeylerine göre değişimini incelemeyi amaçlamıştır. Çalışma, 2012 – 2013 öğretim yılı bahar döneminde Kırşehir ilindeki bir devlet okulunda eğitim görmekte olan 76 yedinci sınıf öğrencisi ile iki hafta süresince yürütülmüştür. Bu çalışmada yarı deneysel araştırma desenlerinden denk olmayan gruplu ön test – son test deneysel deseni kullanılmıştır. Veri toplama araçları olarak bu çalışmada Çevre ve Alan Kavramları için Hazırbulunuşluk Testi, Dörtgenlerde Alan Başarı Testi ve van Hiele Geometrik Düşünme Düzeyi Testi kullanılmıştır. Toplanan veriler iki yönlü varyans analizi (Two Way ANOVA) ile incelenmiştir.

Analiz sonuçlarına göre, uygulanan öğretim yöntemleri ile van Hiele düzeylerinin öğrenci başarısına etkileri arasında bir ilişki olduğu görülmüştür. Ayrıca, dinamik geometri etkinlikleri ile desteklenen matematik öğretiminin öğrenci başarısı üzerine anlamlı bir etkisi olduğu bulunmuştur. Bunlara ek olarak, ikinci van Hiele geometrik düşünme düzeyinde olan öğrencilerin başarı seviyelerinde deney ve karşılaştırma grubu arasında anlamlı bir fark bulunmuştur.

Anahtar Kelimeler: Matematik Eğitimi, Dinamik Geometri Yazılımı, GeoGebra, van Hiele Geometrik Düşünme Düzeyleri, Dörtgenlerde Alan.

To My Grandmother

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AQAT	Area of Quadrilaterals Achievement Test
CAS	Computer Algebra Systems
CG	Comparison Group
DGS	Dynamic Geometry Software
EG	Experimental Group
ESMC	Elementary School Mathematics Curriculum
MoNE	Ministry of National Education
MSMC	Middle School Mathematics Curriculum
NCTM	National Council of Teachers of Mathematics
OECD	Organisation for Economic Co-operation and Development
RTAP	Readiness Test for Area and Perimeter Concepts
PISA	Programme for International Student Assessment
TC	Technology Class
TIMSS	Trends in International Mathematics and Science Study
VHGT	Van Hiele Geometric Thinking
VHLT	Van Hiele Geometric Thinking Level Test

CHAPTER 1

INTRODUCTION

Geometry is one of the important fields of mathematics. Most of the goods and structures in our physical environment are geometric shapes and objects. Geometry can be used solving problems not only in other areas of mathematics but also in science, art and daily life (Aktaş & Cansız-Aktaş, 2012). According to National Council of Teachers of Mathematics (NCTM, 2000), geometry provides describing, analyzing and understanding the world around us. Suydam (1985) stated that geometry is also an important thing as a skill of mathematics. Learning geometry develops students' logical thinking abilities, spatial intuition about the real world, and knowledge for studying higher level mathematical concepts, and reading and understanding of mathematical arguments.

In middle schools, students deal with geometric shapes and structures, their characteristics and relationships with one another in geometry concepts (Umay, 2007). In addition, according to Umay (2007), geometric concepts and geometric thinking are very useful to provide visual representations for other areas of mathematics as well as for daily life situations. The general objectives of geometry education can be defined as: student should use geometry within the process of problem solving, understanding and explaining the physical world around them (Baki, 2001). In order to achieve general objectives of geometry education, learning environments for geometry should be prepared to provide opportunities to students for classifying geometric objects and making deductive reasoning. Understanding of geometry takes very critical role for people's cultural and aesthetic values similar as for understanding mathematics (Baki, 2001; Boyraz, 2008).

Measurement is another important field of mathematics. Measurement is used in many fields in human's life and it has a significance place in communication with other people specifically when describing properties of something with numbers

(Altun, 2008; Tan-Şişman & Aksu, 2009). Moreover, measurement provides important contributions to science and many occupations (Altun, 2008). It connects mathematics to social sciences, science and art (Umay, 2007).

In middle schools, the concepts and skills related to measurement include basic skills and knowledge that students can encounter with them in daily life frequently (Tan-Şişman & Aksu, 2012). In addition, learning measurement has an important place in using mathematics in daily life and in developing many concepts and skills of mathematics (Tan-Şişman & Aksu, 2009, 2012). According to Tan-Şişman and Aksu (2009), taking into account the roles of measurement in mathematics, other sciences and daily life, students should understand means of measuring as well as how to measure.

Measurement and geometry are content areas of Elementary School Mathematics Curriculum (ESMC) (Ministry of National Education [MoNE], 2009a). In ESMC, these content areas listed separately. The ESMC involves five content standards for elementary mathematics which are Numbers, Geometry, Measurement, Probability and Statistics, and Algebra. These five content areas of middle school mathematics are not completely separated from each other. In other words, these content areas are interconnected. For example, Numbers content area is a base for all areas of mathematics. Similarly, some measurement topics are extensions of geometry topics. Altun (2008) stated that geometric skills are needed to measure perimeter, area, length and volume. In other words, most measurement topics in middle school mathematics are related with learning of students in geometry. Some classification and applications of geometry depend on measurement concepts. In addition, measurement concepts involve some applications of mathematics such as number and operations, and it forms a basis for science for students (Altun, 2008; NCTM, 2000).

In early 2013, Ministry of National Education (MoNE) has published a new curriculum for middle school mathematics. In Middle School Mathematics Curriculum (MSMC), geometry and measurement are combined in a single content area, but probability and statistics are separated into two content areas which are

Processing Data and Probability (MoNE, 2013). The current study was conducted with seventh grade students in spring semester of 2012 – 2013 academic year. Since, the MSMC will be implemented to seventh grades in 2015 – 2016 academic year, the study followed the ESMC.

Both ESMC and MSMC are based on a student centered approach (MoNE, 2009a, 2013). Main purpose of these curricula is to help student to construct their own mathematical meanings by their experiences and intuitions, and define concrete and abstract structure of mathematics by using their knowledge (MoNE, 2009a, 2013). In order to prepare suitable learning environments to achieve main purpose of these curriculums, ESMC and MSMC suggest that learning and teaching mathematics should start with concrete experiences and meaningful learning should be aimed. Moreover, these curricula emphasize considering students' motivation and using technology effectively in instructional phases. Collaborative learning and associating learning with other topic and areas are the other important suggestions of ESMC and MSMC.

According to Umay (2007), students need to understand mathematics in order to construct mathematical knowledge and understanding mathematics is achieved with active participation of students. Active learning is the learning process in which students take responsibilities for their own learning, make decisions about the learning process and make self-regulation in the process (Umay, 2007). In other words, active learning can be anything course related which students are active participants of the learning rather than only working, listening and taking notes (Felder & Brent, 2009). The nature of mathematics is suitable this educational perspective. Collaborative learning activities are mostly used in active learning and students have a chance to see different perspectives and solutions of other groups for a situation with collaborative learning (Umay, 2007).

The current study focused on geometry and measurement content standards of middle school mathematics, specifically area concept. Teaching of measuring area concept begins at third grade with non-standard units and beginning from fifth grade, teaching of this concept continues with calculation of area by using standard units (MoNE, 2009a, 2009b, 2013).

1.1. Students' Achievement in Geometry and Measurement Concepts

Middle school students have problems with understanding of area and perimeter concepts, especially situations in which they had to explain or justify their answers (Huang & Witz, 2013; Tan-Şişman & Aksu, 2009, 2012; Zacharos, 2006). In addition, Tan-Şişman and Aksu (2012) stated that seventh grade students have difficulties in using formulas for area effectively. They often understand the concept of area as a multiplication of the length of two sides of a polygon (Kordaki & Potari, 2002; Tan-Şişman & Aksu, 2012). Tan-Şişman and Aksu (2012) also stated that students have misconceptions with area conservation of a shape which is cut into two or more parts and recombined. In addition, the most of the relationships between quadrilaterals are the other concepts that students have difficulty to understand (Fujita & Jones, 2007).

Moreover, there have been several international studies that measure and compare students' achievement and performance in mathematics (Tutak & Birgin, 2008). *Trends in International Mathematics and Science Study (TIMSS)* and *Program for International Student Assessment (PISA)* results indicated that the geometry and measurement achievements of Turkish middle school students are lower than the international average (Ubuz, Üstün & Erbaş, 2009). In TIMSS-R 1999, Turkey ranked 34th for geometry achievement and ranked 32nd for measurement achievement in 38 participating countries (Mullis et al., 2000). In TIMSS 2007, Turkey ranked 30th for general mathematics achievement in 48 participating countries (Uzun, Bütüner & Yiğit, 2010). In PISA 2009, Turkey's average scores in overall were below the Organisation for Economic Co-operation and Development (OECD) average. In PISA 2006, Turkey was 29th in 30 participating OECD countries (Köseleci-Blanchy & Şaşmaz, 2011).

According to Berberoğlu (2004), students in Turkey can perform lower achievement level than students in European Union, and the reasons of this low level achievement can be students' misconceptions, obtaining relevant information for geometry from a single source, and memorizing lots of geometric concepts. Therefore, students cannot see the relationship and implications at given situation and many students are not learning geometry and measurement as they are expected to learn (Berberoğlu, 2004; Mayberry, 1983). Therefore, many students graduated from elementary school without enough knowledge about geometry related topics (Clements & Battissa, 1992; Ubuz & Üstün, 2004). According to Fidan and Türnüklü (2010), a reason for these difficulties and misconceptions can be that geometric thinking level of students are not considered while preparing learning environments.

Literature review revealed that the van Hiele geometric thinking theory is the most common used theory to describe of students' thinking about two-dimensional geometry (Batista, 2002; Olkun, Sinoplu & Deryakulu, 2005). If learning environments prepared by considering students' geometric thinking levels, they can learn geometric concepts sufficiently (Choi-Koh, 1999). In light of these arguments, one aim of the current study is to consider students' geometric thinking levels as independent variable.

In order to deal with these difficulties and misconceptions, Tan-Şişman and Aksu (2012) suggested teaching concepts of measurement rather than formulas, administrating experience-based activities and activities for conservation of area which include cutting and recombining polygons, and forming formulas for area after learning concepts with these activities. In adittion, Fidan and Türnüklü (2010) stated that concepts should be not given directly to students, activities that provide opportunities to students to construct these concepts by their own should be used in learning process. Furthermore, Fujita and Jones (2007) suggested that activities, which provide realizing hierarchical relationships of quadrilaterals and provide opportunities to students for making deductive reasoning, can be used in learning environments. Therefore, learning activities which provide these opportunities were prepared for the current study.

In the current study, learning environments were prepared to make students active participants of learning process and to support collaborative learning. Activities used in the study were prepared considering the suggestions of Fujita and Jones (2007) and Tan-Şişman and Aksu (2012). These activities involve not only relationships between quadrilaterals but also conservation of area concepts. The activities were designed as experience-based activities. In these activities, students formed formulas for area of quadrilaterals after exploring of area concept and observing the situations given in activities. Computer technology can provide such rich activities for addressing these relationships and rules conceptually.

1.2. Technology and Mathematics

In recent decades, the use of technology has increased and changed our life. In every part of our life, we use computers, mobile phones, etc. (Wilken & Goggin, 2012). With the changes in computer technology, educators have started to deal with how computer technology can be integrated into education. Computers can concretize an abstract concept of mathematics by transferring it to screen visually (Tutak & Birgin, 2008). Students can construct their knowledge by using technological educational tools (Tutkun et al., 2012). In mathematics, we can specify technological educational tools as Computer Algebra Systems (CAS), and Dynamic Geometry Software (DGS) (Ruthven, 2009).

The first DGS, called "Geometric Supposer", was developed for the Apple II microcomputer (Oldknow, 2007). Some well-known DGS are GeoGebra, Cabri, and Geometer's Sketchpad (Aytekin & Özçakır, 2012). DGS are tools for mathematicians, like telescope and microscope for scientists, to make new discoveries and test theorems (Oldknow, 2007). Geometry becomes a practical science for also students with the help of DGS. Students can observe, record, manipulate, and predict geometric objects and concepts. In addition, students can test beliefs, ideas and theorems with DGS. (Forsythe, 2007; Hill & Hannafin, 2001). According to Dye (2001), "DGS provides an ideal medium for learning geometry".

The most important characteristic of DGS in contrast to traditional tools is that objects, drawn or constructed, can be moved and resized interactively. The other important characteristics of DGS is that objects constructed with DGS keep their geometric properties while manipulating, such as, a rectangle, constructed correctly by its basic properties will remain a rectangle even its vertices or sides are moved

(Dye, 2001). In other words, students can manipulate the geometric shape by not changing its basic properties and can observe changes with real-time measures (Aydoğan, 2007).

One of the DGS is GeoGebra which was developed by Markus Hohenwarter. GeoGebra is an interactive geometry software for education in schools (Hohenwarter, Hohenwarter & Lavicza, 2010). GeoGebra is a very useful educational tool for nearly all subjects and all levels of mathematics. Because, GeoGebra covers algebra, geometry and calculus (Akkaya, Tatar & Kağızmanlı, 2011; Hohenwarter & Jones, 2007). Geogebra is an open-source and free tool. It has multi-language support. In addition, GeoGebra can be used by basic computer skills (Hohenwarter, Hohenwarter & Lavicza, 2010).

1.3. Purpose of the Study

The purpose of this research is to investigate effects of mathematics instruction supported by dynamic geometry activities and van Hiele geometric thinking levels on students' achievement in area of quadrilaterals.

1.4. Research Questions of the Study

The study focused on the following research questions.

Problem 1. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method and van Hiele geometric thinking levels on seventh grade students' achievement in area of quadrilaterals?

> *Sub-problem 1.1.* What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on seventh grade students' achievement in area of quadrilaterals?
>
> *Sub-problem 1.2.* What is the interaction between effects of instruction based on dynamic geometry activities compared to traditional instruction method and van Hiele geometric thinking levels on seventh grade students' achievement in area of quadrilaterals?

Sub-problem 1.3. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 0, in area of quadrilaterals?

Sub-problem 1.4. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 1, in area of quadrilaterals?

Sub-problem 1.5. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 2, in area of quadrilaterals?

1.5. Significance of the Study

One of the basic suggestions of Mathematics Curriculum of Turkey is usage of technology effectively in instructional phase (MoNE, 2009a, 2013). According to this basis, Ministry of National Education (MoNE) place emphasis on the integration of Information and Communications Technology with education to sustain memorability of information. For this purpose, MoNE has started to set up Technology Classes (TC) in schools (Çelen, Çelik & Seferoğlu, 2011). In addition to TC, MoNE has started a pilot study of F@TIH Project which is about enhancing usage of technology in schools (Tezci, 2011). Instructional technology will be used more efficiently in Elementary and Secondary Schools through the F@TIH Project. As a result of these, instructional tools which based on computer technology will be used in lessons (MoNE, 2011). Although these progresses can provide using computer technology in lessons, useful and various activities based on computer technology for all content areas of mathematics are needed. Considering these developments in the educational policies, this study aimed to develop and use activities about area of quadrilaterals based on dynamic geometry software.

Previous studies indicated that middle school students have problems with understanding of area and perimeter concepts, and have misconceptions with conservation of area (Huang & Witz, 2013; Tan-Şişman & Aksu, 2009, 2012; Zacharos, 2006).

Choi-Koh (1999), and Fidan and Türnüklü (2010) stated that students can learn geometric topics as expected if the learning activities were prepared according to their geometric thinking levels. In addition, Fujita and Jones (2007) stated that activities, which provide realizing hierarchical relationships of quadrilaterals and provide opportunities to students for making deductive reasoning, can be a bridge between van Hiele Level 1 and Level 2. In this sense, in the current study effects of the learning activities were determined. In this way, it was aimed to determine students with which van Hiele geometric thinking level benefits from this type of learning activities. The activities used in the current study generally include hierarchical relationships of quadrilaterals. In this study, van Hiele hierarchy was used as an independent variable in order to investigate whether the hierarchical relationships of quadrilaterals has an effect on students' achievement about area of quadrilaterals or not by providing a bridge between van Hiele Level 1 and Level 2 as Fujita and Jones (2007) stated.

Previous studies indicated that dynamic geometry software or computer based instruction improved students' achievement in mathematics and improved interests and participation to mathematics (Aydoğan, 2007; Baki, Kosa & Güven, 2011; Doğan & İçel, 2011; Gecü, 2011; Güven & Karataş, 2009; Hohenwarter, Hohenwarter & Lavicza, 2010; Şataf, 2011; Toker-Gül, 2008). However, few of them (Işıksal & Aşkar, 2005; Kurak, 2009; Selçik & Bilgici, 2011; Ubuz, Üstün & Erbaş, 2009; Yılmaz et. al., 2009) focused on the effects of dynamic geometry software or computer based instruction on seventh grade students' achievement in mathematics. There still occurs a need to understand how technology enhances seventh grade students' achievement in mathematics.

This study is planned to provide a framework analysis about how technology enhance students' learning in area of quadrilaterals and some information about students' achievements in area of quadrilaterals according to their Van Hiele Geometric Thinking Level. This study addresses the effects of mathematics instruction supported by dynamic geometry activities and van Hiele geometric thinking levels on students' achievement in area of quadrilaterals.

1.6. Hypotheses of the Study

These null hypotheses were used to answer the research question.

Null Hypothesis 1: There is no significant mean difference between the comparison and experimental groups, and van Hiele geometric thinking levels on the population means of students' scores on Area of Quadrilateral Achievement Test.

> *Null Hypothesis 1.1:* There is no significant mean difference between the comparison and experimental groups on the population means of students' scores on Area of Quadrilateral Achievement Test.
>
> *Null Hypothesis 1.2:* There is no significant interaction effect of treatments and van Hiele geometric thinking levels on the population means of students' scores on Area of Quadrilateral Achievement Test.
>
> *Null Hypothesis 1.3:* There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 0, on Area of Quadrilateral Achievement Test.
>
> *Null Hypothesis 1.4:* There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 1, on Area of Quadrilateral Achievement Test.
>
> *Null Hypothesis 1.5:* There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 2, on Area of Quadrilateral Achievement Test.

1.7. Definition of the Important Terms

Quadrilateral: A quadrilateral is a polygon with four sides and corners. It is a closed four sided plane figure (Usiskin et al, 2008).

Dynamic Geometry Software: Dynamic Geometry Software is a computer program which allows a student to create and then manipulate geometric constructions such as points and lines on computer screen. Generally student starts construction by putting a few points and using them to define new objects such as lines, circles or other points. When constructing figures, student can move, drag figures and the properties, geometric relationships are not change (Thomas, 2000).

Computer Based Learning: Computer Based Learning refers to the use of computers as a key component of the educational environment. While this can refer to the use of computers in a classroom, the term more broadly refers to a structured environment in which computers are used for teaching purposes. The concept is generally seen as being distinct from the use of computers in ways where learning is at least a peripheral element of the experience (Lowe, 2004, p.146).

Geogebra: GeoGebra is interactive geometry software for education in schools. It was created by Markus Hohenwarter (Hohenwarter, Hohenwarter & Lavicza, 2010).

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

The goal of this study is to investigate the effects of geometry instruction supported by dynamic geometry activities and van Hiele geometric thinking levels on seventh grade students' achievement in area of quadrilaterals. This chapter is devoted to the review of literature related to this study. The concepts which were covered in this chapter are; geometric thinking of students, quadrilaterals and their classification, area measurement and studies related with Dynamic Geometry Software.

2.1. Geometric Thinking of Students

The difficulties that the students have in learning geometry were noticed by Pierre van Hiele and his wife, Dina van Hiele-Geldof (Mason, 1998; Usiskin, 1982). The van Hieles began thinking the concept, they tried to teach, could be too advanced for their students (Malloy, 2002). In order to deal with students' difficulties in learning geometry, they started to explore the prerequisite reasoning abilities needed for successfully understanding the geometric concepts (Malloy, 2002; Mason, 1998). After their observation, they developed a theory involving students understanding levels of geometry. This theory explains why students encounter difficulties in learning geometry (Malloy, 2002; Usiskin, 1982). According to Crowley (1987), this theory consists of five levels of understanding geometry. These levels are visualization, analysis, informal deduction, formal deduction and rigor. A brief explanation about these levels is presented below (Crowley, 1987; Duatepe, 2004; Malloy, 2002; Mason, 1998; Orton, 2004; Pegg, 1992; Toker-Gül, 2008; Usiskin, 1982).

Level 0 – Visualization: This level is the initial stage of students understanding of geometry. In this level students can name and recognize shapes by their appearance, but cannot specifically identify properties of shapes. For example, student may recognize a geometric figure such as rectangle by it appearances without knowing their properties. Also, he can copy given shapes on paper or geoboard. However, he cannot say that this shape has right angels or has parallel sides.

Level 1 – Analysis: This level is also named as description level. At this level, students begin to identify properties of shapes and learn to use appropriate vocabulary related to properties. However, they cannot make connections between different shapes and their properties. For example, a student at his level can classify a square by some properties, such as having right angles or equal sides. However, they cannot see interrelationships between and among properties, yet.

Level 2 – Informal Deduction: Students in this level are able to recognize relationships between properties (e.g. if in a quadrilateral, opposite angles are equal then opposite sides are parallel) and among properties (e.g. a rectangle is a parallelogram since its opposite sides are parallel). In addition, they are able to follow logical arguments using such properties. Therefore, students can see figures in a hierarchical order if they can achieve this level. Moreover, they can classify figures with minimum sets of properties.

Level 3 – Deduction: At this level, students can go beyond just identifying characteristics of shapes or classifying shapes with a hierarchical order. They are able to construct proofs, using postulates or axioms and definitions, in more than one way.

Level 4 – Rigor: This level is the highest level of thought in the van Hiele hierarchy. Students at this level can work in different geometric or axiomatic systems. They can study with non-Euclidean geometries and different systems.

According to Mason (1998), progress from one level to next level is more related with students' educational experiences than with age or maturation of them, and a student if has not mastered all previous levels, he/she cannot achieve next level.

Understanding students' knowledge at each van Hiele level is important to develop suitable teaching materials, activities and instructions, since students' perception to geometrical concepts is different at all levels (Malloy, 2002; Pegg, 1992). Students at middle grades can be at different levels of understanding. In order to deal with this differentiation, Malloy (2002) suggests that learning activities should include concrete tools, drawing stages and symbolic notations. In brief, in order to develop students understanding in geometry, teachers need to understand the van Hiele levels of their students and they should help them advance through these levels with appropriate learning tools (Malloy, 2002; Mason, 1998; Pegg, 1992).

In geometry and measurement subcategories of TIMSS and geometry of space and figures subcategory of PISA, students in Turkey performed lower level achievement than average achievement level (Mullis et al., 2000; Ubuz, Üstün & Erbaş, 2009; Uzun, Bütüner & Yiğit, 2010). The most important reason of this is that students' geometric thinking levels are not considered while teaching geometry, therefore, students cannot learn geometric concepts sufficiently (Fidan & Türnüklü, 2010). Choi-Koh (1999) stated that if geometric concepts are taught to students by considering their geometric thinking level, they can succeed in geometry.

According to NCTM (2010), student should be achieve first level of van Hiele (Level 0) hierarchy at kindergarten to second grade, second level (Level 1) at third grade to fifth grade, and third level (Level 2) at sixth grade to eight grade. In order to understand mathematical proofs in high school mathematics, students should have achieved third level of van-Hiele hierarchy at elementary school (Cansız-Aktaş & Aktaş, 2012). Fujita and Jones (2007) suggest that hierarchical classification of the quadrilaterals can be used to help students to achieve informal deduction level of van-Hiele geometric thinking.

The van Hiele geometric thinking model has been subject of critics for researchers across the globe (Atebe, 2009; Pegg, 1992). One of the discussions is attaining students into discrete five levels (Pegg, 1992). Although there are evidences that support hierarchical nature of the van Hiele levels (Mayberry, 1983; Pegg, 1992; Usiskin, 1982) there are some opinions about continuity of levels (Atabe, 2009; Pegg, 1992). Moreover, students can be at different levels for different concepts (Pegg, 1992). Other discussions are about difficulties of testing the rigor level of van

Hiele hierarchy and need for a level below the visualization level. In study of Usiskin (1982) 75% of students could be assigned to a level. Usiskin (1982) and Mayberry (1983) were found numbers of students who cannot meet even visualization level of van Hiele hierarchy in their studies. According to Clements and Battista (1992), some of the geometric thinking of students can be primitive than visualization level of van Hiele geometric thinking model. They propose a level which they called as pre-recognition level. Students at this level can realize different between curvilinear and rectilinear shapes but cannot differentiate shapes in same class. In addition, Usiskin (1982) stated that "Level 5 either does not exist or is not testable" about existence or non-existence of rigor level of van Hiele model. Another critique is that if students are assigned into van Hiele levels based on certain criteria, levels of students can change by changing these criteria. Usiskin (1982) demonstrated that a student's level change based on the criteria used, even tasks or questions are still same.

In spite of all these criticisms, the researchers remain optimistic about the possibility of finding ways of improving the geometric understanding of students by considering van Hiele geometric thinking levels (Orton, 2004, p. 183).

2.2. Quadrilaterals and Their Classification

Geometry content area of Elementary School Mathematics Curriculum (ESMC) is focused on developing the relationship between geometric figures by thinking their basic properties. Hence, students should classify geometric figures by using their minimal needed characteristics (i.e. rectangle is a parallelogram with right angles) (MoNE, 2009a). According to Cansız-Aktaş and Aktaş (2012) students can achieve seeing relationships between geometric figures at 3rd van Hiele level. At that level, students recognize square as a special type of rectangle or parallelogram or rhombus.

According to Cansız-Aktaş and Aktaş (2012), ESMC covers the hierarchical relationships of quadrilaterals. In curriculum, rhombus is defined as a parallelogram with perpendicular diagonals, square is defined as a special type of rectangle, and rectangle is defined as a parallelogram with right angles. In addition, in Elementary Mathematics Textbook written by Aygün and others (2011), parallelogram, square and rectangle are defined as a type of trapezoid (p. 221, p. 231). Therefore, we can say that inclusive definition of trapezoid is accepted by ESMC.

Identifying mathematical objects with definitions is very important to develop deductive reasoning and proving of students, since the definitions assign properties to objects and understanding definition of an object requires representing the figure of this object and neighboring objects in order to see similarities and differents (Fujita & Jones, 2007).

According to Usiskin and others (2008), there are two definitions of trapezoid that can be found in mathematics textbooks. First definition is that "A trapezoid is a quadrilateral with exactly one pair of parallel sides". This definition called as exclusive definition. Because, according to this definition, parallelograms are not under of trapezoid in hierarchy of quadrilaterals.

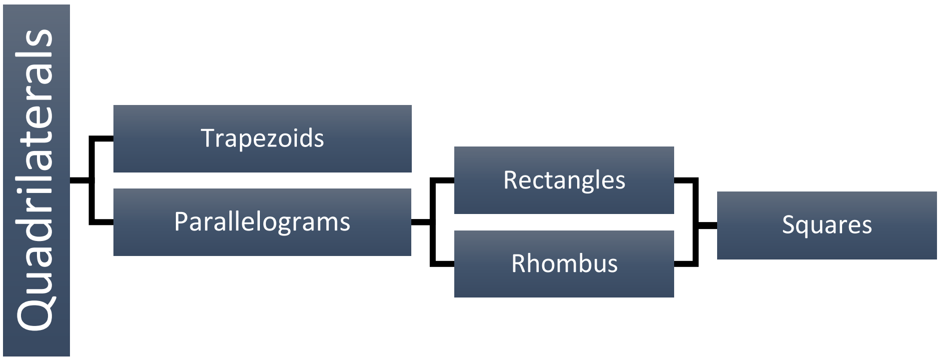

Figure 2.1 An exclusive hierarchy of quadrilaterals with five special types of quadrilaterals.

Second definition of it is that "A trapezoid is quadrilateral with at least one pair of parallel sides". It is inclusive definition of trapezoid and according to this all parallelograms are special type of trapezoid. (Usiskin, et al., 2008).

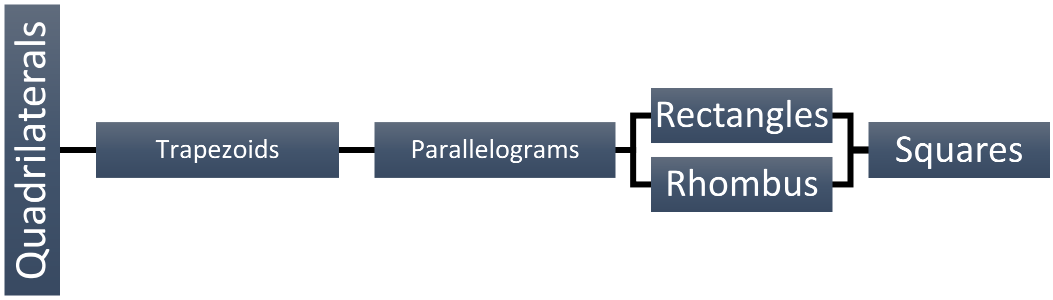

Figure 2.2 An inclusive hierarchy of quadrilaterals with five special types of quadrilaterals.

According to inclusive hierarchy, quadrilaterals can be classified as;

- Square is a regular quadrilateral. All sides and also all angles of it are equal. It is an equiangular and also an equilateral quadrilateral.
- Rectangle is other equiangular quadrilateral. All angles of rectangle are equal.
- Rhombus is a type of equilateral quadrilateral. All sides of rhombus are equal.
- Opposite sides of square, rectangle and rhombus are parallel.
- A quadrilateral with opposite sides parallel is known as parallelogram.
- A quadrilateral with one pair of sides parallel is trapezoid. (Usiskin, et al., 2008; De Villiers, 1996).

The hierarchical classification of quadrilaterals requires logical deduction and suitable interactions between concepts and images (Fujita & Jones, 2007). In other words, students can classify quadrilaterals by their basic properties and can see their relationships, when they achieved the Level 2 of van-Hiele geometric thinking levels (Cansız-Aktaş & Aktaş, 2012). ESMC suggests that student should construct their own knowledge. In order to achieve this, students should attach their former knowledge with newer concepts by recognizing the relationships (MoNE, 2009a). Especially perimeter and area topics in measurements contents area of ESMC, students should be classify and see the relationships of quadrilaterals to find perimeter and area formulas of quadrilaterals. However, according to Olkun and

Aydoğdu (2003) and Aktaş and Cansız-Aktaş (2012), some seventh and eighth grade students cannot see the relationships of quadrilaterals. They have imperceptions to see square or rectangle as a type of parallelogram.

2.3. Area Measurement

Measurement is an essential part of mathematics and it plays an important role in daily life. It is also significant for understanding shapes, determining locations of objects in coordinate system and finding size of an object (Battista, 2007). In other words, measurement can connect not only content areas of mathematics with each other but also mathematics with science and daily life (Altun, 2008; Battista, 2007; Umay, 2007). In addition, learning measurement provides to see usage of mathematics in real world and to develop many skills and concepts of mathematics (Tan-Şişman & Aksu, 2012). In spite of these roles of measurement, students should understand not only meaning of measurement but also doing measurement (Battista, 2007; Chambers, 2008; Tan-Şişman & Aksu, 2009).

Measuring is a process of filling, covering or matching an attribute of an object with a unit of measure with same attribute (Olkun & Toluk Uçar, 2009; Van de Walle, 2007). Measuring has three steps. These are deciding on attribute to be measured, selecting a unit with same attribute, and comparing the units by filling, covering or matching with the attribute of the object which was decided to be measured (Van de Walle, 2007). In other words, firstly students need to decide which attribute of an object to be measured. The attribute can be height, area, volume, weight or time. When they decided on an attribute, they need to select a unit with same attribute to measure. Lastly, they compare the units with the attribute of the object by lining up the units for height, covering the base of the object for area or filling inside of the object with the units for volume (Altun, 2008; Van de Walle, 2007).

One of the mostly used concepts of measurement is measuring area. Area can be defined as “the amount of surface that is enclosed within a boundary” (Baturo & Nason, 1996, p. 238). Area measurement connects numbers content area and measurement content area like other concepts of measurement (Kordaki & Potari, 2002; Tan-Şişman & Aksu, 2009, 2012). According to Reynold and Wheatley

(1996), area measurement has four assumptions. First assumption is that a suitable two-dimensional region is selected as a unit, and secondly, congruent regions of unit have equal areas. Then, the region, which was selected to be measured, is covered by unit regions disjointly (no overlapping). Finally, the sum of areas of unit regions is the area of the union of these disjoint unit regions.

Understanding of area measurement requires comprehending the attribute of area and conservation of area when same region is moved or reshaped, in addition, it requires understanding to measure area by iterating units of area, to use numerical process to determine area for special classes of shapes, and representing the numerical processes with words and algebra (Battista, 2007). Many students cannot comprehend the relationship between unit – measure iteration and numerical measurements (Battista, 2007). Moreover, TIMSS results indicate that students' performance in measurement is lower than any other topics in the mathematics curriculum (Van de Walle, 2007). According to Battista (2007), students' difficulties in measurement should be considered as worrying, since measuring is important for most of real life application of geometry. In addition, Battista (2007) stated that area and surface area performances of students were lower. Similarly, Tan-Şişman and Aksu conducted studies in 2009 with seventh graders and in 2012 with sixth graders about students' performance on topics of perimeter and area. The results of these studies indicated that students have problems with area and perimeter concepts, especially in situations which they had to explain their answers. Similar results were founds by Huang and Witz (2013), and Zacharos (2006). Moreover, Tan-Şişman and Aksu (2012) stated that middle grade students have difficulties in using formulas for area and they have misconceptions with conservation of area which is separated into parts and rearranged. Students commonly understand area as a multiplication of the length of two sides.

According to Van de Walle (2007), the ways of teaching and relying on pictures and worksheets in learning environments rather than hands-on experiences may cause these misunderstanding and difficulties. Since, students have few opportunities to develop their understanding, although they can apply the formulas for area of a polygon in standard problem contexts, they generally cannot apply the formulas in non-standard problem contexts (Battista, 2007; Tan-Şişman & Aksu, 2009, 2012; Zacharos, 2006).

2.4. Studies Related with Dynamic Geometry Software

Dynamic geometry software (DGS) tools are used as classroom tools nowadays. DGS can be helpful while teaching both two-dimensional and three-dimensional geometry (Hohenwarter, Hohenwarter & Lavicza, 2010). Several researchers dealt with the effects of computer based learning with dynamic geometry software. They found that the use of technology as classroom tools is beneficial for students' learning, and developing their understanding in geometry. Because students can explore, conjecture, construct and define geometrical relationship while interacting with DGS (Jones, 2000).

Students have the opportunity to see and explore different construction of an object. DGS can give easier access to lots of geometrical concepts and different views of geometrical constructs than paper and pencil construction. Because students can change or move the shape that they draw and they can see different aspects of it (Aarnes & Knudtzon, 2003).

Hohenwarter, Hohenwarter and Lavicza (2010) aimed to assess the usability of the GeoGebra and to identify features and difficulties of GeoGebra during its introduction to mathematics teachers in their study. They stated that based on feedback and ratings of a Likert scale test workshops was rated feasible and appropriate for the participating teachers. In addition, the participants stated usability and versatility of GeoGebra as user friendly, easy and intuitive to use and potentially helpful to mathematics teachers in written response of questionnaires.

There are many studies about the effects of dynamic geometry software to develop students' understanding and their achievement in mathematics. These studies concluded that use of technology in the mathematics classroom as learning tools is beneficial in developing students' understandings (Boyraz, 2008; Erbaş & Aydoğan - Yenmez, 2011; Filiz, 2009; Güven & Kosa, 2008; İçel, 2011; Köse, 2008; Kurak, 2009; Özen, 2009; Ubuz, Üstün & Erbaş, 2009), enhancing their achievements

(Aydoğan, 2007; Baki, Kosa & Güven, 2011;Demir, 2010; Doktoroğlu, 2013; Ersoy, 2009; Filiz, 2009; Gecü, 2011; Güven & Karataş, 2009; İçel, 2011; Kepceoğlu, 2010; Selçik & Bilgici, 2011; Şataf, 2010; Toker-Gül, 2008; Tutak & Birgin, 2008; Vatansever, 2007; Yılmaz et. al., 2009; Zengin, 2011), and durability of knowledge (Erbaş & Yenmez, 2011; İçel, 2011; Selçik & Bilgici, 2011; Vatansever, 2007).

Kurak (2009) investigated the effects of using DGS on students' understandings levels of transformation geometry and their academic successes. The subjects of study were two different groups of seventh graders in Trabzon. In this study, researcher applied DGS based instruction to experimental group and traditional teaching materials based instruction to control group. Results of study showed that although students' achievements in transformation geometry were not significantly different, understanding levels of students in experimental group was higher than students in control group.

Gecü (2011) investigated the effects of using DGS as a virtual manipulative with digital photographs on achievement and geometric thinking levels at 4th and 8th grade students. In this study, Gecü (2011) found that using DGS as learning tool facilitated students' learning both 4th and 8th grade levels, and improves academic achievement for 4th grade students.

Baki, Kosa and Guven (2011) examined the effects of using DGS Cabri 3D and physical manipulative on the spatial visualization skills of pre-service mathematics teachers. The subjects were selected from undergraduate program in the Department of Elementary Education at the Karadeniz Technical University. There are three groups of subjects. The first experimental group used DGS Cabri 3D as a virtual manipulative, the second experimental group used physical manipulative. The control group received traditional instruction. The physical manipulative and DGS-based types of instruction are more effective in developing the students' spatial visualization skills than the traditional instruction. In addition, they found that the students in the DGS-based group performed better than the physical manipulative-based group.

Toker-Gül (2008) conducted a study to investigate the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and-pencil based guided discovery and traditional teaching method on sixth grade students' van Hiele geometric thinking levels and geometry achievement. The sample of the study consisted of 47 sixth grade students in private schools of Ankara. There were two experimental and one control groups. First experimental group received guided instruction with DGS. Other experimental group received instruction with paper-and-pencil based guided discovery method. The control group received traditional instruction. The results of study indicated that there was a significant effect of using dynamic geometry software while teaching by guided discovery method on students' geometry achievement.

Ubuz, Üstün and Erbaş (2009) conducted a study to compare the effects of instruction utilizing a dynamic geometry environment to traditional lecture based instruction on seventh grade students' learning of line, angle, and polygon concepts. The sample consisted of 15 girls and 16 boys in the experimental group and 17 girls and 15 boys in the control group with ages ranging from 12 to 14 years. A geometry achievement test covering seventh grade geometry topics was prepared to investigate students' achievement in geometry as an instrument. This study has shown that, if used appropriately, dynamic geometry environments as an instruction tool in geometry instruction can improve student achievement in geometry and enhance students' ability of conjecturing, analyzing, exploring, and reasoning.

Aydoğan (2007) conducted a study to investigate the effects of using a dynamic geometry software environment together with open-ended explorations on sixth grade students' performance in polygons and congruency and similarity of polygons. The students in experimental group studied geometric concepts by open-ended explorations in a dynamic geometry software environment while the students in the control group received instruction via traditional methods. Geometry Test and Computer Attitude Scale were used as data collection instruments. The researcher stated that by analyzing pre-test scores there was no significant difference between the groups. On the other hand, the results of the post and delayed posttests which were analyzed by independent sample t-test showed that the experimental group achieved significantly better than the control group in polygons, and similarity of polygons concepts. In addition, the researcher observed a statistically significant correlation between Computer Attitude Scale and Geometry Test. In conclusion, the researcher stated that dynamic geometry software environment together with open-ended explorations significantly improved students' performances in polygons and similarity of polygons.

Yılmaz et. al. (2009) investigated the effect of dynamic geometry software Cabri's on 7th grade students' understanding the relationships of area and perimeter topics. They concluded that a great number of students in treatment group corrected their misunderstandings which they had before the treatment. In addition to this, dynamic geometry based activities enhanced academic success level of students.

Şataf (2011) conducted a study about determining the effect of GeoGebra based instruction on 8th grade pupils' achievements and attitudes. As a result of this study researcher stated that the experimental group achieved high level succession with Geogebra in transformation geometry.

İçel (2011) analyzed the effects of GeoGebra an eighth grade students' achievements in the subjects of triangles. İçel (2011) stated that GeoGebra has positive effects on students' learning and achievement. Moreover, according to results, GeoGebra is effective DGS tool in enhancing the durability of acquired knowledge.

Selçik and Bilgici (2011) conducted a study to investigate the effect of GeoGebra on 7th grade students' achievements in polygons. In this study, the students, participated GeoGebra based instruction group, showed higher level achievement in the subject of polygons. In addition, Selçik and Bilgici (2011) stated that GeoGebra based instruction provides durability of knowledge.

2.5. Summary of the Literature Review

Students' understanding of geometrical concepts is different at each van Hiele geometric thinking level. Therefore, considering students' geometric thinking levels is important while developing suitable teaching materials, activities and instructions. In addition, an appropriate instructional design can be used for developing students' geometric thinking and achievement. Literature review revealed that DGS can provide easier access lots of geometrical concepts and different views of geometrical shapes than paper and pencil construction. Moreover, previous studies indicated that using DGS in learning phase is helpful to develop students' geometric thinking and achievement in mathematics. However, the dynamic geometry software environment cannot evolve and cannot become more beneficial to students in their understanding of geometry without researches that explore the limitations and advantages of them in specific areas.

CHAPTER 3

METHODOLOGY

This chapter explains design of the study, participants, instruments, variables, procedure, teaching and learning materials, treatment, methods for analyzing data, and internal validity of the study.

3.1. Design of the Study

This study was conducted with 7^{th} graders in a public elementary school. Because of school regulations it was not possible to assign students randomly in two groups, so, this study conducted with already intact groups. Therefore, the research questions of the study were examined through nonrandomized control group pretest-posttest design since this study did not include random assignment of participants to comparison and experimental group. Table 3.1 describes the design of the study.

Table 3.1 Research Design of the Study

	Experimental Group	Comparison Group
Pretests	Van Hiele Geometric Thinking Level Test Readiness Test for Area And Perimeter Concepts	
Treatment	Mathematics instruction supported by DGS	Traditional instruction
Posttests	Area of Quadrilateral Achievement Test	

3.2. Participants

The participants in the study were 76 seventh grade students in a public elementary school in Kırşehir. The participants did not learn area of quadrilaterals topic before treatment. This public elementary school was selected for this study conveniently since this school fit for technological requirements of this study. This school had enough number of computers in computer laboratory and the hardware of these computers was sufficient to run GeoGebra effectively. Moreover, mathematics teacher of this school was willing to integrate the GeoGebra into his curriculum. In total, two classes out of five 7th grade classes were selected from this school. In this school classes were not formed according to students' achievements. The distributions of classes in comparison and experimental group and class sizes are given in Table 3.2.

Table 3.2 Groups distributions

Class	Group	Number of Boys	Number of Girls	Total
7/C	Comparison Group	17	19	36
7/B	Experimental Group	20	20	40
Total Number		37	39	76

3.3. Instruments

In order to gather data, three instruments were used in the study: Readiness Test for Area and Perimeter Concepts (RTAP), Area of Quadrilaterals Achievement Test (AQAT), and Van Hiele Geometric Thinking Level Test (VHLT). RTAP and AQAT were developed by researcher and they were piloted before the study to check their reliability, appropriateness, clarity of the items, discrimination of items, and to determine difficulty of questions. The tests and the pilot study are described below.

3.3.1. Readiness Test for Area and Perimeter Concepts

Students' level of mathematics achievement in measurement content area before the treatment was assessed by readiness test for area and perimeter concepts (RTAP) which was a paper-pencil test (Appendix B). The RTAP was developed by researcher to investigate the students' readiness to the topic before the treatment. The RTAP consisted of three objectives of 6th grade mathematics that were;

- explain the relationship between polygons' sides and their perimeter.
- use strategies to estimate area of plane figures.
- solve problems involving area of plane figures.

The RTAP includes 18 multiple-choice questions. The questions of the RTAP were checked for their appropriateness by four researchers with doctoral degree and four graduate students in the field of Elementary Mathematics Education and two elementary mathematics teachers. According to their feedback some changes were made and the RTAP was made ready for pilot study (Appendix A).

3.3.1.1. Pilot Study of RTAP

Participants of pilot study were 139 eighth grade students from Elmalı (Antalya), Bala (Ankara), Yenimahalle (Ankara), and Van. These students were selected conveniently. The eighth graders have learned *Area and Perimeter Concepts* in sixth and seventh grade. Therefore, these students were selected as participants of pilot study.

Distribution of questions of RTAP, which was administrated in pilot study, in objectives was given in Table 3.3.

Table 3.3 Distribution of questions of RTAP in listed objectives

Objectives	Questions
identify relationship between perimeter and side's length of polygons	6, 7, 9
use strategies to estimate area of plane figures	1, 2, 3, 15
solve problems involving area of plane figures	4, 5, 8, 10, 11, 12, 13, 14, 16, 17, 18

According to the results of the pilot study, proportion of correct answers, discrimination index, and point-biserial correlation coefficient of each item were described in Appendix F.

Item difficulty, defined as proportion of students that correctly answered the item, should be greater than .20, and item's discrimination index also should be greater than .20 (Matlock-Hetzel, 1997; Zimmaro, 2003). In addition, according to Varma (2006), point-biserial correlation coefficient should be greater than .25 to be a good classroom test. The difficulty, discrimination-index and point-biserial correlation coefficient of items in the RTAP satisfy these condition, therefore, this test can be considered as a good classroom test (Zimmaro, 2003).

In summary, average difficulty (proportion of correct answers) of the RTAP was found as .54 and discrimination index was found as .53. In addition, the Cronbach Alpha reliability coefficient was found as .81 for the pilot study, which indicates high reliability. After the pilot study, final version of the RTAP was formed by ordering items based on their difficulty levels (Appendix B). The reliability of the test was found as .76 for the current study.

3.3.2. Area of Quadrilaterals Achievement Test

Students' level of mathematics achievement in area of quadrilaterals after the treatment was assessed by Area of Quadrilaterals Achievement Test (AQAT) which was a paper-pencil test (Appendix D). The AQAT was developed by researcher to investigate the students' achievement in the topics after the treatment. The AQAT consisted of seven objectives of 7th grade mathematics that were;

- use strategies to estimate area of quadrilaterals
- form an area formula for parallelogram
- form an area formula for rhombus
- form an area formula for trapezoid
- solve problems involving area of quadrilaterals.
- identify relationship between perimeter and side's length
- identify relationship between perimeter and area

The AQAT included 33 multiple-choice questions before the pilot study (Appendix C). The questions of the AQAT was checked for their appropriateness by four assistant professor, one associated professor, four research assistant and two elementary mathematics teacher. According to their feedback, some changes were made and the AQAT was made ready for pilot study.

3.3.2.1. Pilot Study of AQAT

Participants of pilot study were 139 eighth grade students. Participants of pilot study were 139 eighth grade students from Elmalı (Antalya), Bala (Ankara), Yenimahalle (Ankara), and Van. These students were selected conveniently. The eighth graders have learned *Area and Perimeter Concepts* in sixth and seventh grade. Therefore, these students were selected as participants of pilot study. Seven of these participants were not reachable at AQAT pilot study. Therefore the number of students in this part of pilot study was 132.

According to the results of the pilot study, proportion of correct answers, discrimination index, and point-biserial correlation coefficient of each item were described in Appendix G. Average difficulty of the AQAT was found as .42 and discrimination index was found as .45. In addition, the Cronbach Alpha reliability coefficient was found as .83 for the pilot study, which indicates high reliability. However, proportion of correct answers, discrimination index, and point-biserial correlation coefficient of four items of AQAT was not satisfactory. These questions were not answered correctly by most of the students. Therefore, these questions were excluded from the final version of the test.

The final version of the AQAT was formed by ordering questions based on their difficulty levels (Appendix D). The final version of AQAT included 29 multiple-choice questions. Distributions of questions of the final version of AQAT in objectives were given in Table 3.4.

Table 3.4 Distributions of questions of AQAT in terms of objectives

Topics	Objectives	Questions
Area of Quadrilaterals	use strategies to estimate area of quadrilaterals	15, 17, 23, 29
	form an area formula for parallelogram	1, 2, 4, 8, 10, 11, 14, 16
	form an area formula for rhombus	5, 18, 19, 28
	form an area formula for trapezoid	6, 9, 13
	solve problems involving area of quadrilaterals.	7, 20, 22, 27
	identify relationship between side's length and area	3, 12, 24
	identify relationship between perimeter and area	21, 25, 26

Average difficulty of the last version of the test was found as .43, discrimination index was found as .49, and the Cronbach Alpha reliability coefficient was found as .85 for the pilot study, which indicates higher reliability than former version of AQAT (Appendix C). In addition, the reliability of the test was found as .79 for the current study.

3.3.3. Van Hiele Geometric Thinking Level Test

Students' geometric thinking levels were assessed by van Hiele Geometric Thinking Level Test (VHLT). The VHLT was developed by Usiskin (1982), and translated and validated in Turkish by Duatepe (2000) (Appendix E).

The VHLT was administrated as pretest to understand the initial geometric thinking levels of students before study.

The VHLT consists of 25 multiple-choice questions. Distribution of questions into the van Hiele levels was given in Table 3.5.

Table 3.5 Distribution of questions in to the van Hiele Levels

Van Hiele Level	Questions
Level 0	1, 2, 3, 4, 5
Level 1	6, 7, 8, 9, 10
Level 2	11, 12, 13, 14, 15
Level 3	16, 17, 18, 19, 20
Level 4	21, 22, 23, 24, 25

First 15 questions were considered in the study, since, according to NCTM (2010), students should achieve first three understanding geometry level of van Hiele at elementary school. Usiskin (1982) suggested two criteria for scoring this test. These scoring criteria are three of five correct or four of five correct for each level. In the current study three of five correct answers in each level were used as scoring criterion. In this test, each student was assigned a weighted sum score in the following manner in Table 3.6.

Table 3.6 Scoring van Hiele Geometric Thinking Level Test

	Criteria
1 Point	Three of first five questions of the test are correct
2 Points	Three of second five questions of the test are correct
4 Points	Three of third five questions of the test are correct

These points were added to give the weighted sum. For example, a score of 3 indicates that a student reached the criterion on levels 0 and 1. In this way a score clearly indicates reached levels. However, if a student satisfies the criterion at levels 0 and 2, the students would have a weighted sum of 1 + 4 or 5 points. According to this score, the student cannot be assigned any van Hiele level, since in classical van Hiele theory, a student if has not mastered all previous levels, he cannot achieve next level. Therefore, Usiskin (1982) suggested a modified scoring method which was also used in the current study. In Table 3.7 assigning levels for 25 questions was described by modified van Hiele Level method.

Table 3.7 Modified van Hiele Level

	Weighted Sum
Level 0	1 or 17
Level 1	3 or 19
Level 2	7 or 23
Level 3	15 or 31

This modified scoring method was converted for first 15 questions which were considered for the current study. According to this scoring method, if student take 1 point or 5 point in this test, he is assigned in Level 0 of van Hiele Geometric Thinking, if a student take 3 points, he is assigned to Level 1, and if a student take 7 points, he assigned to Level 2. In this test, the maximum score is 7 and minimum is 0. In addition, the Cronbach Alpha reliability coefficients range between .31 to .49 in the study of Usiskin (1982) and .27 to .35 in this study for each five questions. According to Usiskin (1982), reason for the low reliabilities is the small number of items. In this study the reliability of this test for all questions was .72.

3.4. Variables

Variables of this study can be categorized as independent variables, dependent variable and covariate.

3.4.1. Independent Variables

In this study there were two independent variables. One of them was the treatment which was mathematics instruction supported by dynamic geometry activities and regular instruction of the class. The other independent variable was the scores of VHLT. The scores of VHLT were divided into three categories which were van Hiele geometric thinking Level 0, Level 1 and Level 2.

3.4.2. Dependent Variable

Dependent variable of the study was students' scores on area of quadrilaterals achievement test (AQAT).

3.4.3. Covariate

Possible covariate of this study was students' scores on readiness test for area and perimeter concepts (RTAP). These scores were analyzed whether a significant difference between comparison and experimental groups existed or not. The results were described in *Results* section.

3.5. Procedure

This study was conducted in a public school, in the context of a seventh grade mathematics course designed to teach the topic of area of quadrilaterals. The study was designed as a quasi-experimental study. In this study there were two different groups – experimental (EG) and comparison group (CG), and accordingly there were two different teaching and learning environments which were DGS supported instructional environment for EG and traditional instructional environment for CG.

For this study, GeoGebra software was used as a tool in EG. The students in EG worked on area of quadrilaterals with GeoGebra based activities. On the other hand, the CG learned the same topic by traditional instruction environment based on the official 7^{th} grade mathematics textbook of MoNE from Semih Ofset / S.E.K Press (Toker, 2012).

Lesson plans and activity sheets were developed by considering the objectives of the seventh grade mathematics suggested by MoNE. These activities were prepared to allow students to learn specified topics by manipulating given situation in GeoGebra and to construct their own knowledge by exploring relationships between polygons namely quadrilaterals. Lesson in EG was conducted by using the instructional materials given in Appendix H and Appendix I. These instructional materials were checked by two elementary mathematics teachers, two graduate students and a researcher with doctoral degree in the field of elementary mathematics education, in terms of the clarity of the directions and appropriateness of the content.

The study was carried out in the second semester of the 2012 – 2013 academic year. The study lasted two weeks. In the CG, teacher taught the topics of area of quadrilaterals to students by using textbook. In the EG, students worked with the activity sheets developed by the researcher and GeoGebra. The activities were studied in computer laboratory. In the first week of the study, GeoGebra preparation course was implemented for students and teacher in order to teach the basics of the software. For this purpose, a manual for GeoGebra was prepared by the researcher. This manual was involved basic features of GeoGebra for doing the activities (Appendix J).

There were three achievement tests in this study. The readiness test for area and perimeter concepts (RTAP) was administrated to students as pretest, and the area of quadrilaterals achievement test (AQAT) was administrated as posttest to both of the groups to see their accomplishments in the topics. In addition, the van Hiele geometric thinking level test (VHLT) was administrated to students before the study, in order to categorize students into the van Hiele geometric thinking levels. RTAP and AQAT were developed by researcher according to objectives of measurement content area of mathematics curriculum. Before the main study, a pilot study was conducted to check appropriateness, clarity, difficulty, discrimination power of items and to check the reliability of tests. The time allotted for the administration of the tests was one lesson hour for each. An outline of the procedure of the study is given in Table 3.8.

Table 3.8 Outline of the procedure of the Study

	Experimental Group	Comparison Group	Time Schedule
Before Study	GeoGebra Preparation Course		25 / 02 / 2013
Pretests	Van Hiele Geometric Thinking Level Test Readiness Test for Area and Perimeter Concepts		26 / 02 / 2013
Treatment	Mathematics instruction Supported by DGS	Traditional Instruction	01 / 03 / 2013 12 / 03 / 2013
Posttests	Area of Quadrilaterals Achievement Test		15 / 03 / 2013

The students in both groups were taught the same mathematical contents with same pace. Treatment period lasted 8 lesson hours. Lessons of CG were conducted in their regular classrooms. On the other hand, lessons of EG were conducted in a computer laboratory.

3.6. Treatment

The students in CG studied the topic of area of quadrilaterals with traditional instructional environment as usual while the EG learned same topic with GeoGebra based activities, in the treatment phase. The instructional environments in these groups are explained in detail in the following section.

3.6.1. Treatment in the Comparison Group

The lessons of comparison group were held in students' regular classroom. Their mathematics teacher taught the topics to students. Researcher only observed lessons in comparison group.

Area of quadrilaterals topic was taught to students in comparison group by following official 7th grade textbook of MoNE published by Semih Ofset / S.E.K. Press (Toker, 2012). Traditional type of instruction was dominant although the textbook has been prepared based on the new curriculum (MoNE, 2009). In this textbook there were many activities based on student centered approach. However, these activities were not applied in the comparison group. Only some activities about area of parallelogram, area of rhombus and area of trapezoid were shown to students by drawing on the board by teacher. For example, in the first lesson, teacher firstly drew a grid on the board and drew a parallelogram on this grid. He asked students to estimate the area of parallelogram. After estimations, he drew an altitude to the parallelogram from one upper vertex to base and showed formed right triangular part on parallelogram. Then he drew a new triangle, which was congruent to the one that had been formed on the other side, at the end of the parallelogram and removed the formed right triangular part (Figure 3.1). After, he asked to students to estimate the new shape area which was rectangular. He made students to realize the relationship between parallelogram and rectangle.

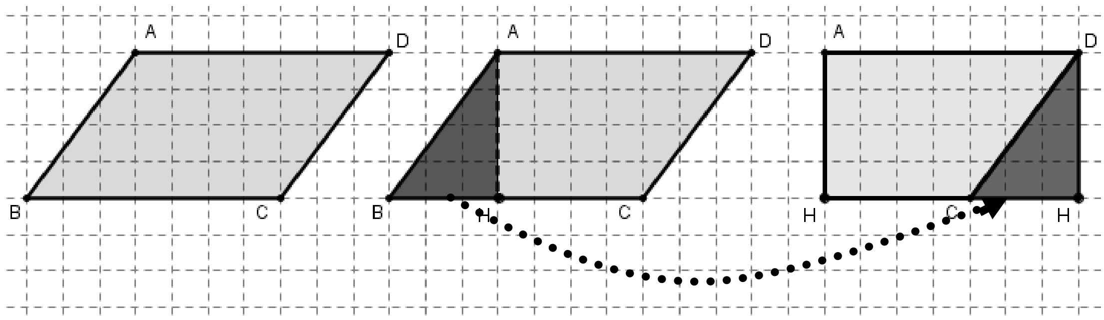

Figure 3.1 Area of parallelogram in comparison group

The other activities in the textbook were given as homework assignment to students in comparison group.

At the beginning of the each new subject, lessons began with discussion. For instance, teacher encouraged students to discuss about similar questions to these: “what is the parallelogram?”, “what are the properties of the parallelogram?” and “how can we measure the area of a figure?” for the subject of area of parallelogram. Generally, the teacher gave definitions of concepts by writing properties and if necessary, by drawing figures on the board and then he allowed students to write them on their notebooks. Then he wrote questions on the board and let students try to solve these questions at their places. In question solving part of lessons, a few students were volunteers to explain their solutions to class. Some of the volunteers explained their solutions for questions. Then teacher also explained solutions of the questions to class. When the subject was completed the activities and exercises in the textbook were given as homework assignment to students in comparison group.

3.6.2. Treatment in the Experimental Group

Lessons of experimental group were held in the computer laboratory (Figure 3.2). In the computer laboratory, students explored the topics by using GeoGebra software with worksheets which were developed by the researcher according to activities in students' mathematics textbook (Appendix H).

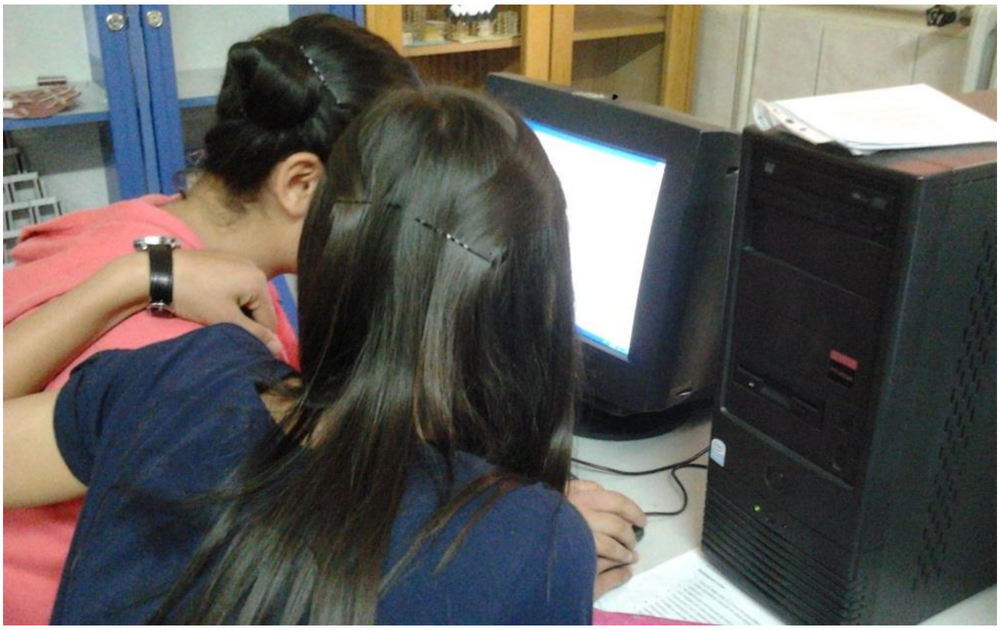

Figure 3.2 Students were working on an activity in EG

Area of quadrilaterals topic were taught to students in EG with GeoGebra based activities during the treatment period. In computer laboratory, there were 18 computers. Students worked in groups of 2 and 3. There were 14 two-student groups and 4 three-student groups. Therefore, the treatment of experimental group may be affected by collaborative learning.

Most of the students were not familiar with GeoGebra. In order to familiarize students to GeoGebra a preparatory instruction was given.

The GeoGebra was used as learning tool for students in experimental group. The activity sheets included directions to use GeoGebra. Firstly, students manipulated geometric figures and objects such as parallelogram, rhombus, trapezoid and square, according to directions. Then, they tried to answer questions in activity sheets. They tried to explore relationships between quadrilaterals and their areas by following directions in activity sheet.

In first minutes of the lessons, the content of the lesson was introduced to students, and some explanations about activities were given to students. Then students started activities. In appendix H the worksheets for these lessons were presented. The teacher gave feedback on the students' errors and guide about their questions during the activities. Researcher planned to be an observer during the activities, however, some students had troubles with computer usage and teacher was not able to help these students. Therefore, sometimes the researcher served as a technical assistant during treatment.

The activities in the study were prepared based on the given activities on textbook. The purpose of the researcher was to make the activities on textbook to interactive dynamic activities. Therefore, similar activities to the textbook activities were designed. The activities were designed as easy as possible to use GeoGebra. Students did not have to construct any geometric objects in these activities, since needed geometric objects were constructed while preparing activities. Students only moved objects or used buttons in the activities by following directions on activity sheets. A brief explanation about the activities and their objectives were given in Table 3.9.

Table 3.9 Brief explanation about the activities and their objectives

Activity	Objective	Description & Administration	Expected Results
Area of Parallelogram	form an area formula for parallelogram	There are three movable points in this activity. Students move points according to directions on activity sheet and fill tables on activity sheets with measures of lengths of sides, altitudes, perimeter and area.	Students realize the relationships between bases, altitude and area. Students form an area formula for parallelogram by analyzing the data on the tables.
The Relationship between Parallelogram and Rectangle	use strategies to estimate area of quadrilaterals	There are a parallelogram and its altitude. Base point of the altitude is movable. In addition there is a button for cutting parallelogram into two pieces across through the altitude. After cutting the parallelogram there will be two figures. The figure at the left is movable and students move this figure by following directions on activity sheet. After moving a button will appear which is about combining these figures to form a rectangle. After combining students can start over and move altitude to different position and can do same things for the new position of altitude.	Students estimate area of parallelogram and check their estimations from area of rectangle. Students understand area conservation. Students realize the relationships between parallelogram and rectangle.

Table 3.9 (Continued)

Area of Rhombus	form an area formula for rhombus	There are a rhombus in a rectangle and a button which separate triangular parts at outside the rhombus from rectangle. After separation, another button will appear which rotates these triangular parts by 180°. After rotation, another button will appear which combine these rectangular parts to form a rhombus over the first rhombus. Students answer questions on the activity sheet.	Students realize the relationships between area of rectangle and area of rhombus or area of triangle and area of rhombus. Students form an area formula for rhombus by using these relations.
Area Relationship between Rhombus and Parallelogram	use strategies to estimate area of quadrilaterals	There are a rhombus and a button which copies the rhombus. After copying, a button will appear which rotates rhombus by forming similar view of parallelogram. Students answer questions on the activity sheet.	Students estimates area of rhombus and check their estimations from area of parallelogram. Students realize the relationships between rhombus and parallelogram.
Area of Trapezoid	form an area formula for trapezoid	There are four movable points in this activity. Students move points according to directions on activity sheet and fill tables on activity sheets with measures of lengths of sides, altitudes, perimeter and area.	Students realize the relationships between bases, altitude and area. Students form an area formula for trapezoid by analyzing the data on the tables.

Table 3.9 (Continued)

Area Relationship between Trapezoid and Parallelogram	use strategies to estimate area of quadrilaterals	There are a trapezoid and a button which copies the trapezoid. After copying, a button will appear which rotates trapezoid by 180°. This rotated trapezoid at right can be movable. Students move this figure according to directions on the activity sheet. Students answer questions on the activity sheet.	Students estimates area of trapezoid and check their estimations from area of parallelogram. Students realize the relationships between area of trapezoid and area of parallelogram.
The Relationship between Area and Perimeter	identify relationship between perimeter and area	There is a rectangle, and its upper right vertex can be movable. Students move points according to directions on activity sheet and fill tables on activity sheet with measures of lengths of sides, perimeter and area.	Students realize the relationships between perimeter and area.
The Relationship between Side Length and Area	identify relationship between side's length and area	There is a rectangle, and its upper right vertex can be movable. Students move points according to directions on activity sheet and fill tables on activity sheet with measures of lengths of sides, perimeter and area.	Students realize the relationship between side's length and area.

Three activities in experimental group were described below in detail.

First lesson was about area of parallelogram. A sample view of Geogebra screen for this lesson was shown in Figure 3.3.

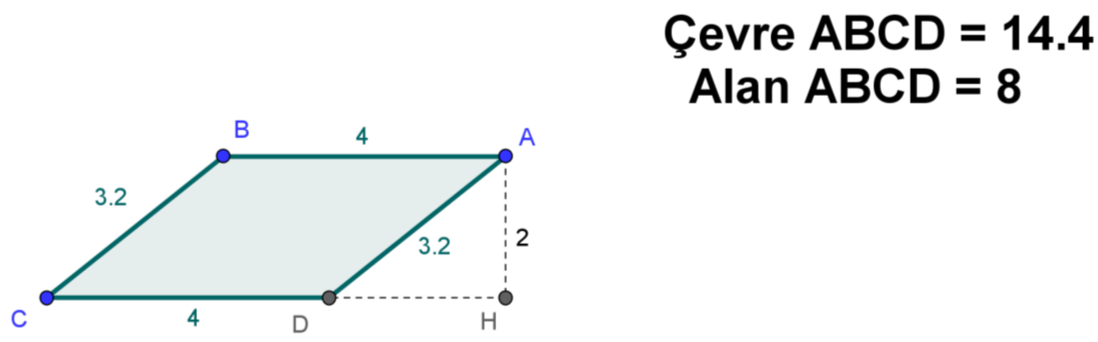

Figure 3.3 Geogebra screen for area of parallelogram activity *[Çevre: Perimeter; Alan: Area]*

In GeoGebra file for this activity, point A moves upward and downward, point B and point C moves right and left. When student moves point A, height of parallelogram is changing but base of this height remains the same. When point B is moved, height remains same but this time base of this height is changing. If point C is moved both height and its base remains same, so the area remains same. In activity, it was wanted to students change all three points in five situation and recode findings in tables. In this activity some students find a formula to measure area of parallelogram by analyzing data in the tables in the worksheet. Moreover, few of them realized the relationship between parallelogram and rectangle, and formed a formula for area of parallelogram from this relationship. At the end of the activity students let to change the points freely, and they tried to explore many situations about these points to verify their formulas.

The activity of third lesson was about area of rhombus. An example of the view of GeoGebra screen was shown in Figure 3.4.

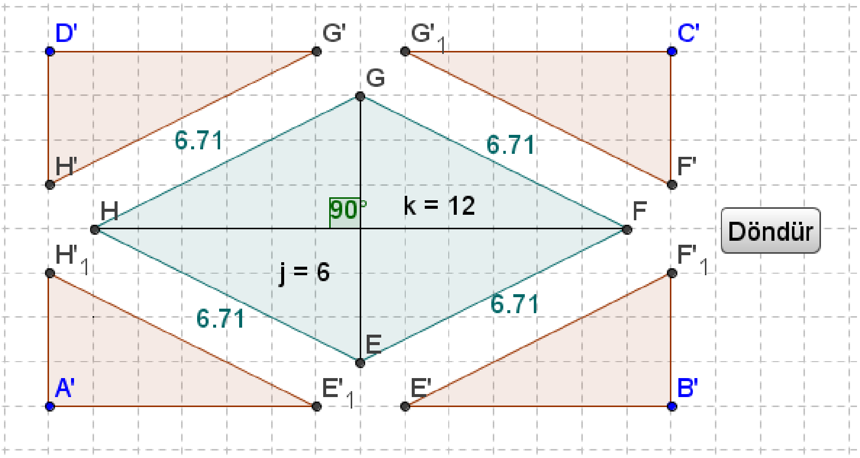

Figure 3.4 GeoGebra screen for area of rhombus activity *[Döndür: Rotate]*

This activity was different from first activity. This activity involved both relationship between rectangle and rhombus, and relationship between right triangle and rhombus. At the end of this activity, some students formed a formula by using area of right triangles, and few of the formed a formula by using relationship between rectangle and rhombus.

The fifth lesson was about area of trapezoid. This activity was similar to the first lesson's activity which was about area of parallelogram. A sample view of GeoGebra screen was presented in Figure 3.5.

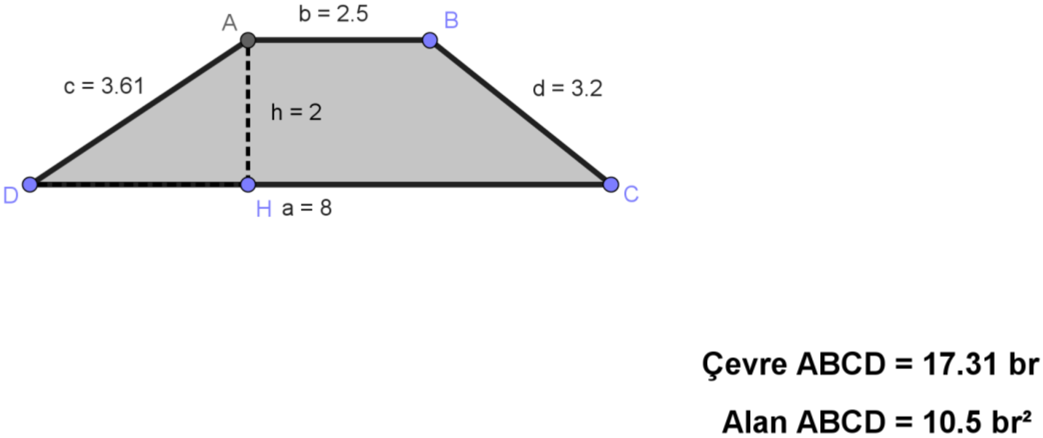

Figure 3.5 GeoGebra screen for area of trapezoid activity *[Çevre: Perimeter; Alan: Area]*

In GeoGebra file for this activity, point B, C and D moves rightward and leftward, and point H moves upward and downward. When student moves point B, upper base of trapezoid is changing but height and lower base of trapezoid remain same. If point C is moved, lower base of trapezoid is changing but both height and upper base remains same. If point H is moved, height of trapezoid is changing but both upper and lower bases remains same. When student moves point D, upper base, lower base and height remains same, so the area remains same. In activity, students were asked to change all four points in five situations and record findings in tables. In this activity some students find a formula to measure area of trapezoid by analyzing data in the tables in the worksheet, but they could not clarify their answer. Their explanation about the area formula was the middle number between lengths of upper and lower bases multiply with height. In the end of the activity, teacher helped students to form the formula by asking “How can we find the middle number of two numbers?”. At the end of the activity students let to change the points freely, and they tried to explore many situations about these points to verify their formulas. At this phase of the lesson some students came up with this idea “The quadrilaterals are similar. I can construct rectangle, parallelogram, rhombus and square by using this activity. I can compute area of these quadrilaterals by using area formula of trapezoid”.

In these activities, students did not have any difficulty, in other words, they used the GeoGebra for these activities, easily. Students were active participants in learning process. They explored and explained their ideas freely. Therefore, they could construct their own understanding of geometry. Since these activities were implemented as group activities, there were both in group discussion and in class discussion.

The comparison of roles of teacher, roles of researcher, roles of students and environment in the experimental and comparison groups was given in Table 3.10 briefly.

Table 3.10 The roles and environments in the experimental and comparison groups

Groups	Environment	Roles of teacher	Roles of researcher	Roles of students
Experimental Group	Computer Laboratory	Guide the students when necessary Monitor the students' work Give feedback on students' responses	Observer Technical Assistant	Deal with activity sheets Deal with GeoGebra Make discussions in group and between groups
Comparison Group	Regular Classroom Environment	Give information Present the topics Solve questions	Observer	Take notes Listen teachers Answer questions

3.7. Data Analysis

Means, medians, standard deviations, skewness and kurtosis as descriptive statistics were used to investigate the general characteristics of the sample.

The data gathered through the RTAP, AQAT, and VHLT were analyzed by using Statistical Package for Social Science (SPSS) 17.0. A two-way analysis of variance (ANOVA) procedure was employed to answer the research questions. Before the two-way ANOVA, independent sample t-test was conducted to analyze whether there exists a significant difference between scores of RTAP of students in comparison and experimental groups. The hypotheses were tested at 95% confidence interval.

3.8. Internal Validity

Internal validity refers to the degree to which observed differences on the dependent variable are directly related to the independent variables not to some other (Frankel & Wallen, 2009). In this section, a list of possible threats to internal validity and how they can be controlled are discussed.

In this study, students were not assigned randomly to the experimental and comparison group which can cause the subject characteristics threat to the study. Students' previous achievement in measurement and geometry was determined and these scores were used to analyze whether any statistically differences between groups existed or not. In addition, the achievement tests were administrated to all students in their own regular classes. Therefore, location threat was also reduced by satisfying similar conditions in all classes during the administrations of the instruments.

Testing threat may not affect the study, because, different achievement tests were administrated as pretest and posttest. RTAP was pretest, and AQAT was posttest of the study.

Since, the treatment period was 8 lesson hours and both groups were treated for same duration; maturation may not be a threat to internal validity of this study. Therefore, if there was any maturation threat to the study, it affected all groups.

Attitude of subjects' threat also affected the study. The researcher was an observer during treatment to reduce effect of attitude of subjects' threat. Teachers of comparison and experimental groups taught lessons and administrated tests.

3.9. External Validity

In this study, subjects selected conveniently; therefore, the generalizability of the study was limited to subjects who have similar characteristics and similar conditions. The achievement tests were administrated in students' regular classroom, and classrooms had similar conditions with each other. Moreover, all instruments and treatments were administrated regular lesson hours of students’ mathematics lessons. Therefore, ecological threats to validity were controlled. Researcher was an observer during the treatment phases; therefore, experimenter effect may not threat the study.

3.10. Limitations of Study

The study is not a true experimental study since the participants were not assigned to the experimental and the comparison groups randomly. The study was conducted on seventh grade students in Kırşehir. The activities in learning environment were based on GeoGebra. Students worked in groups for experimental group, since the class was relatively crowded and computers were not enough. If it were less crowded, students might have more experiences with GeoGebra. On the other hand, working in groups might have provided them a discussion environment. The results of the study are limited to the population with similar characteristics and similar environments.

CHAPTER 4

RESULTS

This chapter presents descriptive and inferential statistics related to research questions.

4.1. Descriptive Statistics and Data Cleaning

4.1.1. Descriptive Statistics of RTAP and AQAT for Comparison and Experimental Groups

Descriptive statistics related to the Readiness Test for Area and Perimeter Concepts (RTAP) and Area of Quadrilaterals Achievement Test (AQAT) for comparison and experimental groups were presented in the Table 4.1.

Table 4.1 Descriptive statistics related to the RTAP and AQAT for comparison and experimental groups

	Groups	N	Min.	Max.	Mean	Median	SD	Skewness	Kurtosis
RTAP	CG	36	8	18	13,33	14	3,171	-,233	-1,113
	EG	40	8	18	14,25	15	3,002	-,493	-,826
AQAT	CG	36	16	29	22,39	22	3,499	,007	-0,910
	EG	40	14	29	24,57	26	3,915	-1,126	,451

As seen on the Table 4.1, the mean score of RTAP for experimental group (*M = 14.25*, *SD = 3.00*) was relatively higher than the mean score of RTAP for comparison group (*M = 13.33, SD = 3.17*). In addition, the mean score of AQAT for experimental group (*M = 24.57, SD = 3.92*) was relatively higher than the mean score of AQAT for comparison group (*M = 22.39, SD =3.50*).

In order to analyze whether there exists any outliers, the clustered boxplot was drawn. The boxplot for RTAP and AQAT for comparison and experimental groups was presented in Figure 4.1.

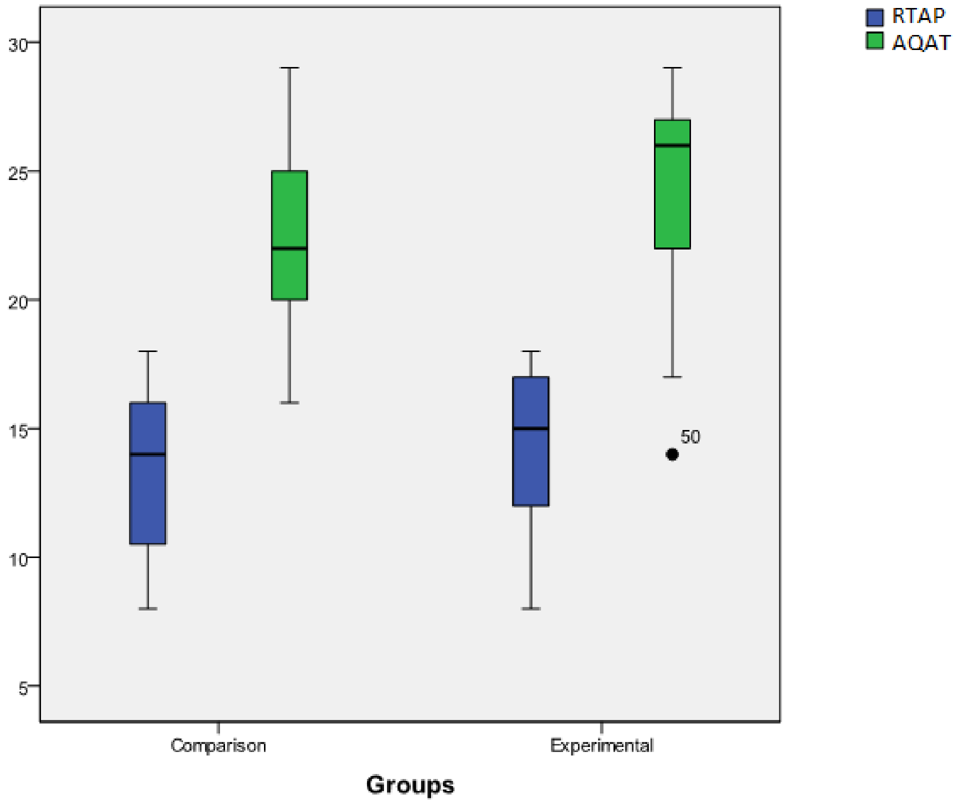

Figure 4.1 The box plot for RTAP and AQAT for groups

As the figure indicated, there was a lower outlier in the AQAT of the EG. In boxplot, a box represents the scores from the lower to upper quartile, the line in the box represents the median of the scores, and each T-bars, namely inner fences or whiskers, represents upper 25% and lower 25% of the scores. The mean of AQAT for experimental group, which was 24.57, was lower than the median, which was 26. This outlier may be caused by this lower mean. In addition, median of AQAT for experimental group was higher than the upper quartile of the AQAT for comparison group.

4.1.2. Descriptive Statistics of RTAP and AQAT for VHLT Categories

Descriptive statistics related to the RTAP and AQAT for all students in VHLT categories were presented in the Table 4.2.

Table 4.2 Descriptive statistics related to the scores from RTAP and AQAT for all students together in VHLT categories

	Groups	N	Min.	Max.	Mean	Median	SD	Skewness	Kurtosis
RTAP	Level 0	16	8	14	10,31	10	1,887	,707	-,009
	Level 1	28	8	18	13,75	14,5	2,977	-,455	-,702
	Level 2	32	11	18	15,63	16	2,012	-,537	-,703
AQAT	Level 0	16	14	24	19,31	18,5	2,983	,033	-1,178
	Level 1	28	17	29	22,96	22	3,666	,040	-1,212
	Level 2	32	22	29	26,16	26	1,851	-,341	-,036

According to the Table 4.2, the mean score of RTAP for students in Van Hiele Geometric Thinking (VHGT) Level 2 ($M = 15.63$, $SD = 2.01$) was relatively higher than the mean score of RTAP for both students in VHGT Level 1 ($M = 13.75$, $SD = 2.98$) and students in VHGT Level 0 ($M = 10.31$, $SD = 1.89$). In addition, the mean score of AQAT for students in VHGT Level 2 ($M = 26.16$, $SD = 1.85$) was relatively higher than the mean score for both students in VHGT Level 1 ($M = 22.96$, $SD = 3.67$) and students in VHGT Level 0 ($M = 19.31$, $SD = 2.98$). Moreover, the minimum scores of AQAT for students in VHGT Level 2 was 22 out of 29 where the minimum scores of AQAT for students in VHGT Level 1 was 17 out of 29 and for Level 0 was 14 out of 29.

In order to analyze whether there exists any outliers, the clustered boxplot was drawn. The boxplot for RTAP and AQAT for VHLT categories was presented in Figure 4.2.

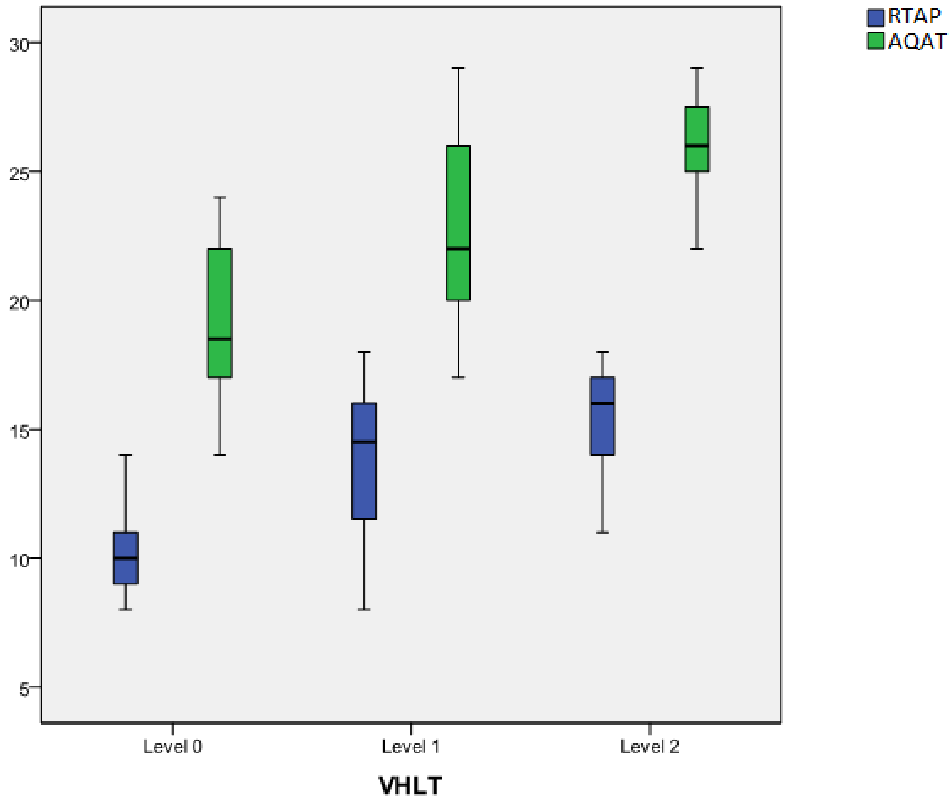

Figure 4.2 The box plot for RTAP and AQAT for VHLT categories

As the figure indicated, there was no outlier for RTAP and AQAT for VHLT categories. The medians of RTAP and AQAT for VHGT Level 2 were nearly same with the upper quartile of the RTAP and AQAT for VHGT Level 1, respectively. In addition, the lower quartile of RTAP and the median of AQAT for VHGT Level 1 were nearly same with the upper quartile of RTAP and AQAT for VHGT Level 0, respectively.

4.1.3. Descriptive Statistics of RTAP and AQAT for VHLT Categories in Comparison and Experimental Groups

Descriptive statistics related to RTAP and AQAT for VHLT categories in comparison and experimental groups were presented in Table 4.3 and Table 4.4, respectively.

Table 4.3 Descriptive statistics related to RTAP for VHLT categories in comparison and experimental groups

	VHLT	N	Min.	Max.	Mean	Median	SD	Skewness	Kurtosis
CG	Level 0	8	8	14	10,75	10,5	1,151	,613	-,909
	Level 1	14	8	16	12,29	12,5	2,946	-,179	-1,566
	Level 2	14	13	18	15,86	16	1,875	-,250	-1,407
EG	Level 0	8	8	12	9,88	10	1,458	-,086	-1,187
	Level 1	14	11	18	15,21	15	2,259	-,356	-,779
	Level 2	18	11	18	15,44	16	2,148	-,655	-,609

Table 4.4 Descriptive statistics related to AQAT for VHLT categories in comparison and experimental groups

	VHLT	N	Min.	Max.	Mean	Median	SD	Skewness	Kurtosis
CG	Level 0	8	16	23	19,88	20	2,748	-,157	-1,779
	Level 1	14	17	26	20,57	20	2,503	,640	,256
	Level 2	14	22	29	25,64	25	1,946	,78	-,475
EG	Level 0	8	14	24	18,75	17,5	3,284	,359	-,672
	Level 1	14	18	29	25,36	26	3,054	-1,095	1,241
	Level 2	18	22	29	26,56	26	1,723	-,688	1,709

As seen on the Table 4.3, the mean score of RTAP for students in VHGT Level 2 in CG (*M = 15.86*, *SD = 1.88*) was relatively higher than the mean score for both students in VHGT Level 1 (*M = 12.29*, *SD = 2.95*) and students in VHGT Level 0 (*M = 10.75*, *SD = 1.15*). Moreover, the mean score of RTAP for students in VHGT Level 2 in EG (*M = 15.44*, *SD = 2.15*) was relatively same with the mean score of AQAT for students in VHGT Level 1 (*M = 15.21*, *SD = 2.26*), and was relatively higher than students in VHGT Level 0 (*M = 9.88, SD = 1.46*). In addition to these, the mean score of RTAP for students in VHGT Level 2 in CG (*M = 15.86, SD = 1.88*) and VHGT Level 2 in EG (*M = 15.44, SD = 2.15*) were nearly same. However, the mean score of RTAP for students in VHGT Level 1 in EG (*M = 15.21, SD = 2.26*) was relatively higher than the mean score for VHGT Level 1 in CG (*M = 12.29, SD = 2.95*), and the mean score for students in VHGT Level 0 in EG (*M = 9.88, SD = 1.46*) was relatively lower than the mean score for VHGT Level 0 in CG (*M = 10.75, SD = 1.15*).

According to the Table 4.4, the mean score of AQAT for students in VHGT Level 2 in EG (*M = 26.56, SD = 1.72*) was relatively higher than the mean score of AQAT for both students in VHGT Level 1 (*M = 25.36, SD = 3.05*) and students in VHGT Level 0 (*M = 18.75, SD = 3.28*). In addition, the mean score of AQAT for students in VHGT Level 2 in CG (*M = 25.64, SD = 1.95*) was relatively higher than the mean score for both students in VHGT Level 1 (*M = 20.57, SD = 2.50*) and students in VHGT Level 0 (*M = 19.88, SD = 2.75*). Moreover, the mean score of AQAT for students in VHGT Level 2 (*M = 26.56, SD = 1.72*) and VHGT Level 1 (*M = 25.36, SD = 3.05*) in EG were relatively higher than the mean score of AQAT for students in VHGT Level 2 (*M = 25.64, SD = 1.95*) and VHGT Level 1 (*M = 20.57, SD = 2.50*) in CG, respectively. However, the mean score of AQAT for students in VHGT Level 0 in CG (*M = 19.88, SD = 2.75*) was relatively higher than the mean score for VHGT Level 0 in EG (*M = 18.75, SD = 3.28*). Moreover, the minimum scores of AQAT for students in VHGT Level 2, Level 1 and Level 0 in EG were 22, 18 and 14 out of 29 respectively where the minimum scores of AQAT for students in VHGT Level 2, Level 1 and Level 0 in CG was 22, 17 and 16 out of 29 respectively.

In order to analyze whether there exists any outliers, the clustered box plot was drawn. The box plot for RTAP and AQAT for VHGT categories in comparison and experimental groups were presented in Figure 4.3.

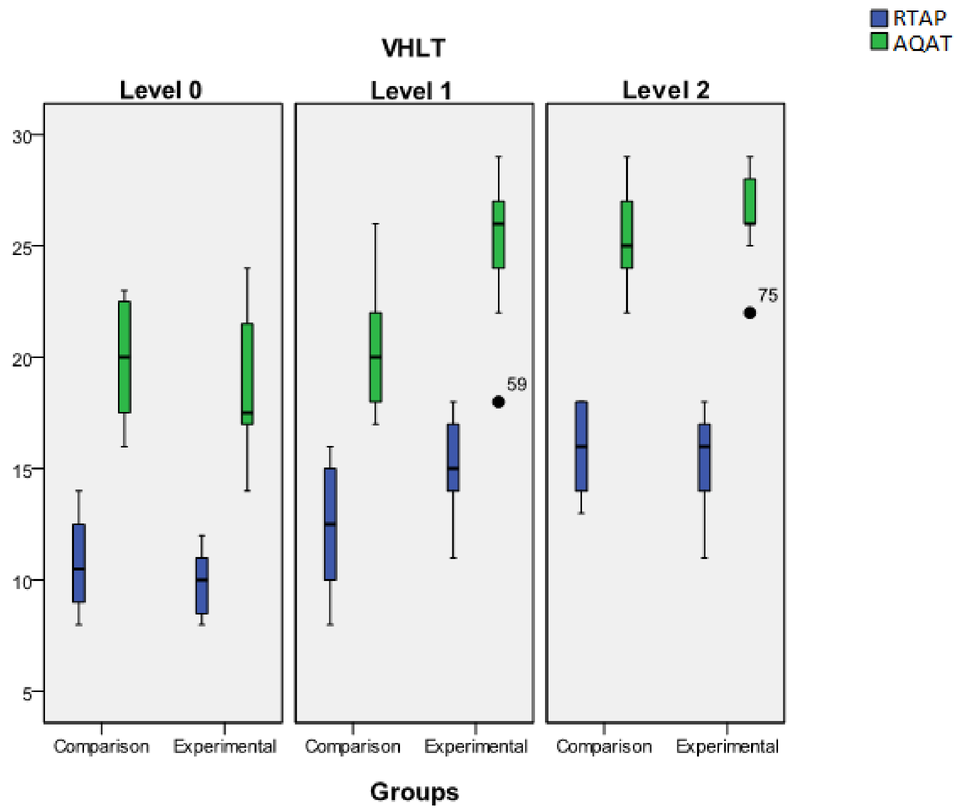

Figure 4.3 The box plot for RTAP and AQAT for VHLT categories in comparison and experimental groups

As the figure indicated, there were two lower outliers in the AQAT of VHGT Level 2 and Level 1 in EG. In addition, the lower quartile of AQAT of VHGT Level 1 in experimental group was higher than the upper quartile of the AQAT of VHGT Level 2 for comparison group.

4.1.4. Data Cleaning

There were three outliers in data. The data had been checked whether this value had been entered correctly and this checking was concluded that the data were correct. These outliers may affect the two-way analysis of variances. Field (2009) suggests that if outliers were detected, there were several options to reduce the effect of these values. One of them is deleting the subject's scores from data. In order to analyze subjects' score Cook statistics was calculated. The simple boxplot for Cook's Distance was presented in Figure 4.4.

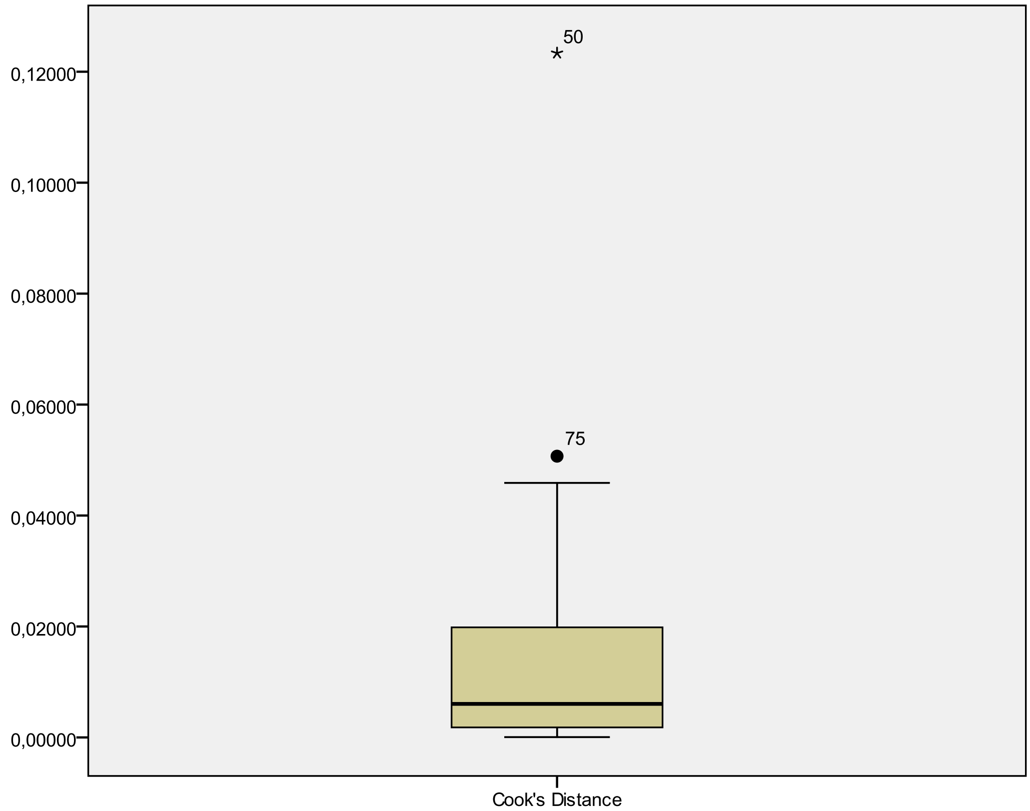

Figure 4.4 Cook’s distance for the scores of AQAT for VHLT categories in comparison and experimental groups

As it was represented in the figure, 50th subject was an extreme outlier. This value was considered for deletion. An independent sample t-test was conducted to see how this outlier affected the study before and after deletion in terms of students’ prior knowledge. The assumptions of independent sample t-test were described below.

RTAP was scaled as continuous measures, so, all score of the test were in ratio level. In order to assess normality, skewness and kurtosis values of RTAP were examined and they were listed in Table 4.1.

According to Cameron (2004), if data are normally distributed, skewness and kurtosis values should fall in the range from -2 to +2. Since, skewness and kurtosis values were in acceptable range, normality assumption was satisfied. In the study, the researcher observed both comparison and experimental groups during administration of RTAP. All students answered all test by themselves.

The results of independent sample t-test were presented in Table 4.5.

Table 4.5 The results of independent sample t-test for RTAP scores for before and after deleting subject 50.

		Levene's Test		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.
RTAP (Before deletion)	Equal variances assumed	,164	,687	-1,294	74	,200	-,917
	Equal variances not assumed			-1,290	72,122	,201	-,917
RTAP (After deletion)	Equal variances assumed	,513	,476	-1,546	73	,127	-1,077
	Equal variances not assumed			-1,539	70,643	,128	-1,077

As seen on Table 4.5, significance values of Levene's test for equal variances are larger than .05. Therefore, equal variance assumption was satisfied. Before deleting the subject's scores from data, there was no significant mean difference between in scores of RTAP for comparison group (*M = 13.33, SD =3.17, N = 36*) and for experimental group (*M = 14.25, SD = 3.00, N* = 40), t(74) = -1.29, p = .20. Similarly, after deleting the subject's scores from data, there was no significant mean difference between in scores of RTAP for comparison group (*M = 13.33, SD =3.17, N = 36*) and for experimental group (*M = 14.41, SD = 2.86, N* = 39), t(73) = -1.55, p = .13. Since, deleting this subject from data was not effect initial status of study, this subject was deleted from data in order to deal with outlier.

After this changing the descriptive statistics of the data were presented below in Table 4.6.

Table 4.6 Descriptive statistics for AQAT after deletion of the extreme outlier

	Categories	N	Min.	Max.	Mean	SD	Skewness	Kurtosis
AQAT Groups	CG	36	16	29	22,39	3,499	,007	-,910
	EG	39	17	29	24,85	3,565	-1,049	,214
AQAT VHLT	Level 0	15	16	24	19,67	2,717	,209	-1,623
	Level 1	28	17	29	22,96	3,666	,040	-1,212
	Level 2	32	22	29	26,16	1,851	-,341	-,036
AQAT VHLT for CG	Level 0	8	16	23	19,88	2,748	-,157	-1,779
	Level 1	14	17	26	20,57	2,503	,640	,256
	Level 2	14	22	29	25,64	1,946	,078	-,475
AQAT VHLT for EG	Level 0	7	17	24	19,43	2,878	,690	-1,355
	Level 1	14	18	29	25,36	3,054	-1,095	1,241
	Level 2	18	22	29	26,56	1,723	-,688	1,709

4.2. Inferential Statistics

This part covers the missing data analysis, determination of analysis, assumptions of analysis of variance, results of analysis of variance and the follow-up analysis related to study.

4.2.1. Missing Data Analysis

There were no missing data in RTAP, VHLT and AQAT. However, there were a few questions which were not answered by some students. These questions were coded as wrong answer during the analysis.

4.2.2. Determination of Analysis

Before the study, RTAP, which was designed as readiness test, was conducted to determine previous mathematics success level of students as possible confounding variable of the study. The scores of RTAP were analyzed whether RTAP can be taken as covariate in order to adjust the differences between groups.

An independent sample t-test analysis was conducted to understand whether comparison and experimental groups differed significantly in terms of their RTAP scores. The result of independent sample t- test for RTAP was presented in Table 4.7.

Table 4.7 The results of the independent sample t-test for RTAP scores

		Levene's Test		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.
RTAP	Equal variances assumed	,513	,476	-1,546	73	,127	-1,077
	Equal variances not assumed			-1,539	70,643	,128	-1,077

According to this analysis, there was no significant mean difference between in scores of RTAP for comparison group (*M = 13.33, SD =3.17, N = 36*) and for experimental group (*M = 14.41, SD = 2.86, N* = 39), t(73) = -1.55, p = .13. Therefore, comparison and experimental groups were not statistically different before treatment. Since there was no need to adjust scores in groups, scores of RTAP did not assigned as covariate and a two-way analysis of variance was conducted in order to answer research questions.

4.2.3. Assumptions of ANOVA

The ANOVA model assumes below-listed properties are verified (Tabachnick & Fidell, 2007).

i. Level of measurement

ii. Normality

iii. Homogeneity of variance

iv. Independence of observations

Both RTAP and AQAT were scaled as continuous measures, so, all score of these test were in ratio level. In addition, result of VHLT was coded in three discrete categories. In order to assess normality, skewness and kurtosis values of AQAT were examined and these values are represented in Table 4.6. According to Cameron (2004), if data are normally distributed, skewness and kurtosis values should fall in the range from -2 to +2. Since, skewness and kurtosis values were in acceptable range, normality assumption was satisfied.

Homogeneity of variance assumption was controlled by Levene's Test of Equality Error Variances. The results are listed Table 4.8.

Table 4.8 Levene's Test of Equality Error Variances for AQAT

	F	df1	df2	Sig.
AQAT	1,635	5	69	,162

As seen on Table 4.8, significance value for AQAT is .16 and since, this value is greater than .05, homogeneity of variance assumption has not been violated.

In the study, the researcher observed both comparison and experimental groups during all phases of study included administration of pretest and posttest. All students answered all test by themselves.

4.2.4. Analysis of Variance

The purpose of this research is to provide insight into the effects of mathematics instruction supported by dynamic geometry activities on students' achievement in area of quadrilaterals and students' achievements according to their van Hiele geometric thinking levels. The following research questions were investigated:

Problem 1. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method and van Hiele geometric thinking levels on seventh grade students' achievement in area of quadrilaterals?

Sub-problem 1.1. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on seventh grade students' achievement in area of quadrilaterals?

Sub-problem 1.2. What is the interaction between effects of instruction based on dynamic geometry activities compared to traditional instruction method and van Hiele geometric thinking levels on seventh grade students' achievement in area of quadrilaterals?

Sub-problem 1.3. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 0, in area of quadrilaterals?

Sub-problem 1.4. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 1, in area of quadrilaterals?

Sub-problem 1.5. What are the effects of instruction based on dynamic geometry activities compared to traditional instruction method on achievement of seventh grade students, at van Hiele geometric thinking level 2, in area of quadrilaterals?

A two-way (2 x 3 factorial) analysis of variance was conducted to assess effectiveness of using dynamic geometry software in mathematics instruction, specifically the topics of area of quadrilaterals. The null hypotheses for inferential statistics were presented below:

Null Hypothesis 1: There is no significant mean difference between the comparison and experimental groups, and van Hiele geometric thinking levels on the population means of students' scores on Area of Quadrilateral Achievement Test.

Null Hypothesis 1.1: There is no significant mean difference between the comparison and experimental groups on the population means of students' scores on Area of Quadrilateral Achievement Test.

Null Hypothesis 1.2: There is no significant interaction effect of treatment and van Hiele geometric thinking level on the population means of students' scores on Area of Quadrilateral Achievement Test.

Null Hypothesis 1.3: There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 0, on Area of Quadrilateral Achievement Test.

Null Hypothesis 1.4: There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 1, on Area of Quadrilateral Achievement Test.

Null Hypothesis 1.5: There is no significant mean difference between the comparison and experimental groups on the population means of scores of students, at van Hiele geometric thinking level 2, on Area of Quadrilateral Achievement Test.

An alpha level of .05 was used for the initial analyses. The results of two-way analysis of variance were listed in Table 4.9.

Table 4.9 The results of two-way analysis of variance for scores of AQAT

	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	51,299	1	51,299	8,742	,004	,112
VHLT	440,801	2	220,400	37,560	,000	,521
Group * VHLT	85,801	2	42,900	7,311	,001	,175
Error	404,891	69	5,868			

Total	43033,000	75

The results for the two-way ANOVA indicated that there was a significant interaction effect between the scores of VHLT and the treatments, on the scores of AQAT, F (2,69) = 7.31, p < 0.5, partial eta squared = .18. That was indicating that any differences between the categories of VHLT were dependent upon which group students were in. Interaction was graphed in Figure 4.5. Approximately 18% of total variance of scores of AQAT was attributed to the interaction of groups and scores of VHLT and this indicated a large effect size. In addition to this, results showed that a significant main effect for scores of VHLT on the scores of AQAT, F(2,69) = 220.40, p < .05, partial eta squared = .52, and partial eta squared indicated a large effect size. Moreover, the results indicated a significant main effect of comparison and experimental groups on score of AQAT, F(1,69) = 8.74 , p <.05, partial eta squared = .11, and partial eta squared pointed out medium effect size.

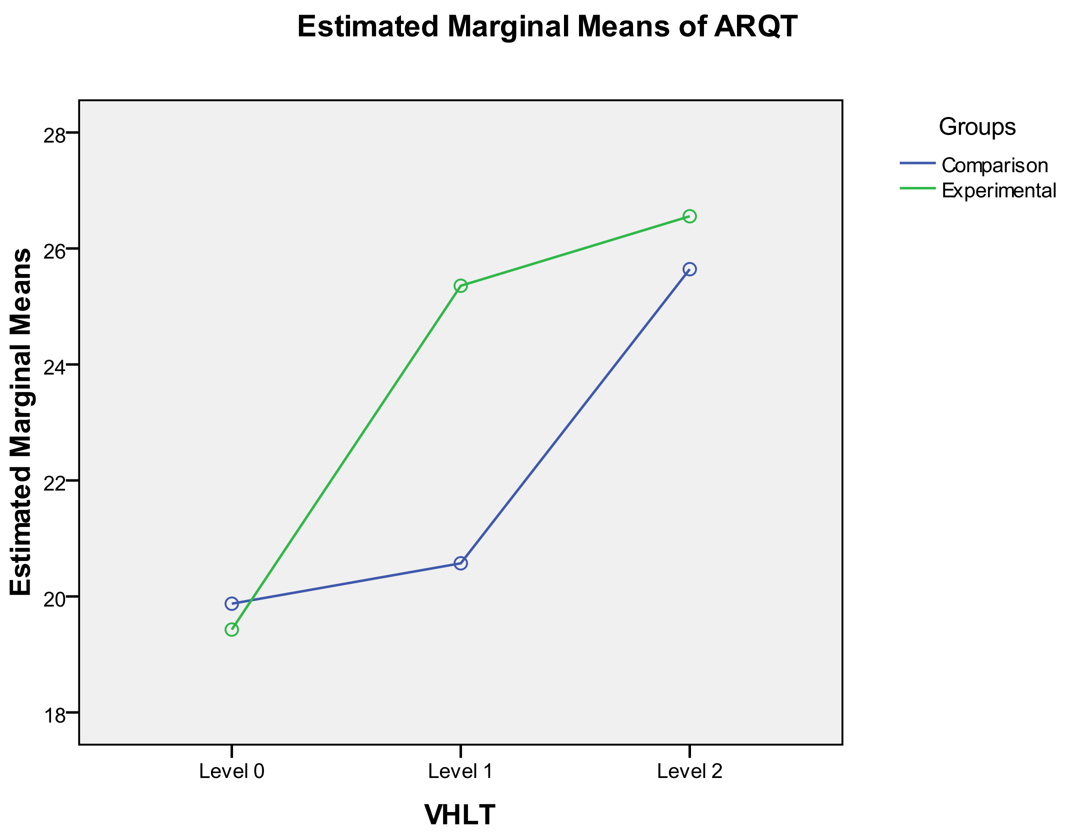

Figure 4.5 Interaction of groups and scores of VHLT in terms of scores of AQAT.

Figure 4.5 clearly shows that the mean score of AQAT of students in VHGT Level 1 in EG was significantly higher than students in VGHT Level 1 in CG.

4.2.5. Follow-up Analysis

The results of a significant interaction effect were followed up by running tests for simple interaction effects. The following SYNTAX was used to analyze the mean difference in scores of AQAT between groups at each van Hiele geometric thinking level.

```
UNIANOVA AQAT BY Group VHLT

/EMMEANS TABLES(Group*VHLT) COMPARE(Group)
```

The univariate test results were shown in Table 4.10.

Table 4.10 Simple main effects analysis

		Sum of Squares	Df	Mean Square	F	Sig.
Level 0	Contrast	,744	1	,744	,127	,723
	Error	404,891	69	5,868		
Level 1	Contrast	160,321	1	160,321	27,321	,000
	Error	404,891	69	5,868		
Level 2	Contrast	6,560	1	6,560	1,118	,294
	Error	404,891	69	5,868		

This table points out whether there are statistical differences in mean score of AQAT between groups for each van Hiele geometric thinking level. As it is seen on table, there were no statistically significant mean differences between comparison and experimental groups' scores in AQAT when students at VHGT Level 0 (p = *.723*). Similarly, there were no statistically significant mean differences between comparison and experimental groups' scores in AQAT when students at VHGT Level 2 (p = *.294*). However, when students are at VHGT Level 1, there were significant differences between comparison and experimental groups' scores in AQAT (*p* < *.05*). In summary, this result shows that students in VHGT Level 1 in EG benefited from the treatment more than students in VGHT Level 0 and Level 2.

4.3. Summary

A two-way ANOVA was conducted to examine the effect of comparison and experimental groups, and van Hiele geometric thinking level in scores of AQAT. The dependent variable, scores of AQAT, was normally distributed for groups formed by the combination of the van Hiele geometric thinking levels, and comparison and experimental groups as assessed by skewness and kurtosis values. There was homogeneity of variance between groups as assessed by Levene's test. The results indicated a significant main effect of comparison and experimental groups on scores of AQAT, $F(1,69) = 8.74$, $p < .05$. Moreover, there was a significant interaction between the effects of comparison and experimental groups, and van Hiele geometric thinking level on scores of AQAT, $F(2,69) = 7.31$, $p < 0.5$. Simple main effects analysis indicated that students in experimental group were significantly more successful in AQAT than students in comparison group when in VHGT Level 1 (*p* < *.05*). However, there were no significant mean differences between students in comparison group and students in experimental group when in VHGT Level 0 (*p* = *.723*) or VHGT Level 2 (*p* = *.294*).

CHAPTER 5

DISCUSSION AND IMPLICATIONS

This chapter was devoted to present the discussion of the results, implications, and recommendations for further studies.

5.1. Discussion of the Results

The purpose of this research was to investigate the effects of mathematics instruction supported by dynamic geometry activities on students' achievement in area of quadrilaterals and on students' achievements according to their van Hiele geometric thinking levels. GeoGebra was used as dynamic geometry software for this study.

The topic of area of quadrilaterals at 7^{th} grade mathematics curriculum was covered in this study. The topic of area of quadrilaterals involved area of parallelograms, area of rhombus, area of trapezoids, relationship between perimeter and area and relationship between side length and area subtopics.

There were eight activities for these subtopics in the study. The worksheets and GeoGebra screen views of these activities were presented in the Appendix H and Appendix I. In this study, the subjects were categorized by using two independent variables which were treatments and van Hiele geometric thinking levels.

One of the findings of the study indicated that the usage of dynamic geometry software (DGS) in mathematics instruction had a positive effect on students' scores in the Area of Quadrilaterals Achievement Test (AQAT) in favor of the mathematics instruction supported by dynamic geometry activities. The possible reasons of this enhancement can be that the activities were designed in order to maximize usability of GeoGebra easily and the usage of its dynamic features. In addition, the activities were prepared to make the manipulation of the figures easy. According to Jones (2000), students can explore, conjecture, construct and realize geometrical relationships while interacting with DGS. In addition to this, students have a chance to see different views of an object in DGS easily in comparison to paper and pencil construction (Aarnes & Knudtzon, 2003). In activities, students in experimental group (EG) had a chance to see different views of parallelograms, rhombuses and trapezoids. They explored relationships between quadrilaterals by following directions which listed in worksheets and also freely at the end of the all lessons. All of the activities were about relationships among quadrilaterals and their connections to each other. These explorations the relationships and connections among quadrilaterals through GeoGebra resulted in higher level of achievement in the topic of area of quadrilaterals for students in EG. This result was consisted with the results of Yılmaz and others (2009) who investigated the effect of DGS on 7^{th} grade students understanding the relationship of area and perimeter topics. They found that with help of DGS, a great number of students had corrected their misunderstanding and their success level in area and perimeter topics increased.

The other finding of the study was that, there was a significant interaction between the effects of treatments and van Hiele geometric thinking (VHGT) level on scores of AQAT. Clearly, this result indicates, if there is a significant differences between experimental group and comparison group, this different depends on students' van Hiele geometric thinking levels. This result was followed up and this follow up analysis revealed that students in EG were significantly more successful in area of quadrilaterals than students in comparison group (CG) who were at VHGT Level 1. However, there was no significant mean difference in scores of AQAT between students in CG and students in EG who were at VHGT Level 0. Similarly, there was no significant mean difference in scores of AQAT between students in CG and students in EG who were at VHGT Level 2.

Students in VHGT Level 0, namely *Visual Level*, can identify shapes according to their examples and appearances; in Level 1, *Analysis or Description Level*, can identify given figure and describe its properties, and in Level 2, *Abstract or Informal Deduction Level*, can identify relationships between shapes and can produce simple logical deduction. The hierarchical relationships of quadrilaterals can be regarded as a difficult task for students in Level 0 and Level 1 (Fujita & Jones, 2007). The hierarchical relationships require seeing relationships among figures, so logical deduction. Fujita and Jones (2007) suggested that hierarchical relationships of the quadrilaterals can be used to help students to move from shape properties to geometrical properties, namely relationship among shapes and their properties. The activities in the current study were about relationship among quadrilaterals. For example, the first and second activities involved relationships between parallelogram and rectangle, the third activity involved relationships between rhombus and rectangle, the forth activity involved relationships between rhombus and parallelogram, the fifth activities involved relationships between trapezoid, parallelogram and rectangle, and the sixth activities involved relationships between trapezoid and parallelogram. In addition, the first and fifth activities involved manipulating side lengths of parallelogram or trapezoid by preserving their basic properties. Moreover, the fourth and sixth activities covered different views of rhombus and trapezoid in order to deal with students' prototype shapes. All of these activities were related with the hierarchical relationships of quadrilaterals.

The possible reason of the improvements of the achievements of students at van Hiele geometric thinking level 1 in EG can be that these activities may help them progressing from shape properties to geometrical properties by using hierarchical relationships of quadrilaterals. This result was consisted with the results of Fujita and Jones (2007). The possible reason of the similar success levels for students at van Hiele geometric thinking level 2 in CG and EG can be that students in Level 2 already achieved logical deduction level of van Hiele hierarchy and they can see the interrelationships among shapes. Moreover, they can understand the hierarchical relationships of quadrilaterals according to classical van Hiele theory (Atebe, 2009; Usiskin, 1982). Students at van Hiele geometric thinking level 2 in comparison group learned area of quadrilaterals topic by traditional learning environment nearly same level with students in experimental group, since they were able to see the relationships between quadrilaterals. The other result of the follow up analysis was similar success levels for students at van Hiele geometric thinking level 0 in CG and EG. The possible reason of these similar success levels can be that these students were at the visualization level, so they can name shapes by their appearances.

Students at van Hiele geometric thinking level 0 in experimental group did not benefited from treatment sufficiently, since these students were not ready to understand the hierarchical relationships of quadrilaterals according to classical van Hiele theory (Atebe, 2009; Usiskin, 1982). Therefore, students' achievements were the nearly same level in both groups. In addition, students in level 0 may be influenced by their prototype images of quadrilaterals.

5.2. Implications

Mathematics curriculum in Turkey suggests using visualization and concrete representations. Dynamic geometry software (DGS) is a useful tool to make abstract concepts to concrete representations. In addition, different views of a shape or relationships among shapes can be explored by manipulating shapes in DGS. DGS also provides real time measures for perimeter, area or angles for manipulated shapes. Therefore, students can easily explore and analyze how the shapes change or what measures change when manipulating, and they can understand the relationships among shapes which is the basic requirement for van Hiele geometric thinking level 2.

In this study, the results indicated that using GeoGebra in area of quadrilaterals improved students' achievements. In addition to this, using GeoGebra activities which based on hierarchical classification of quadrilaterals had positive effects on students' achievements, specifically at van Hiele geometric thinking level 1. Clearly, according to Fujita and Jones (2007) and the results of this study, the usage of GeoGebra activities based on hierarchical classification of quadrilaterals can be considered a bridge between van Hiele geometric thinking level 1 and level 2. Therefore, teachers can apply dynamic activities based on GeoGebra or other dynamic geometry software in instructional phase while teaching area of quadrilaterals topic in order to improve both students' achievements and geometric thinking especially when their students are at van Hiele geometric thinking level 1.

In the mathematics curriculum and F@TIH Project, effective technology usage is emphasized. However, there is not enough activities which integrate technology in teaching and learning process. As the results indicated the usage of DGS in mathematics instruction is helpful to improve students' understanding and achievement in Mathematics, specifically in the topic of area of quadrilaterals. Therefore, curriculum developers and textbook writers should develop more computer based activities or examples how teachers should integrate technology in teaching and learning process. In addition to them, the GeoGebra activities took time during the students reach generalizations by exploring and building their own knowledge. The presented lesson hours for objectives in mathematics curriculum were nearly sufficient to administrate the activities. Therefore, in order to use GeoGebra or other DGS based activities in teaching and learning process the presented lesson hours for objectives should be revised for this manner.

5.3. Recommendations for Further Research

This study provides a framework analysis about how technology enhances students' learning of some mathematical concepts and some information about students' achievements in mathematics according to their van Hiele geometric thinking level, and how technological tools such as GeoGebra may influence students' understanding of geometry. This study focused on area of quadrilaterals topic of seventh grade mathematics. Therefore, this study only included the usage of dynamic geometry software in the topic of area of quadrilaterals and achievements of the seventh grade students. In order to analyze the effects of GeoGebra in other topics and other grade levels, further research should be conducted. In addition, this study examined the effect of GeoGebra to students' achievement according to their van Hiele geometric thinking levels. In this study, GeoGebra activities had effects only students at van Hiele geometric thinking level 1. In order to examine the effects of GeoGebra to other van Hiele geometric thinking levels different activities should be developed and research should be conducted.

GeoGebra which is a DGS was used as a learning tool in this study. The effect of other DGS in same topic and same grade should be examined to understand their effects on seventh grade students' achievements on area of quadrilaterals.

This study was lasted for eight lesson hours. Therefore, the long-term effects of using GeoGebra on students' achievements in mathematics and their achievements regarding van Hiele hierarchy should be investigated in further research.

Since this study did not include random sampling methods, its results were limited to similar conditions and this study was conducted relatively small number of participants. Therefore, new studies should be conducted with larger and randomly selected participants in order to test its results for these conditions.

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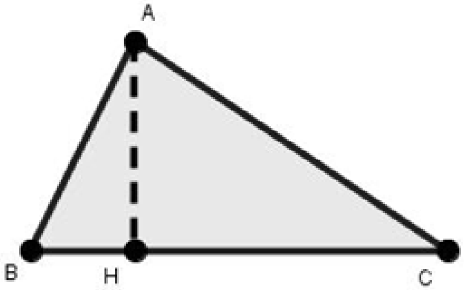
APPENDICES

APPENDIX A

FORMER VERSION OF READINESS TEST FOR AREA AND PERIMETER CONCEPTS

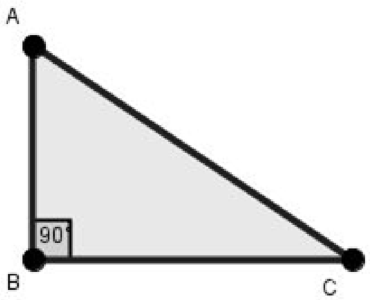
1.



Yukarıda verilen üçgensel bölgede,
[AH] ⊥ [BC], |AH| = 2 cm ve |BC| = 4 cm
olduğuna göre,
ABC üçgensel bölgesinin alanı kaç cm^2 dir?

A) 2 cm^2 B) 4 cm^2
C) 6 cm^2 D) 8 cm^2

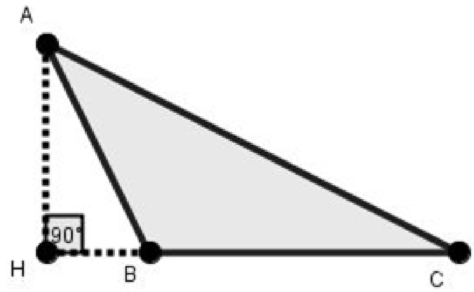
2.



Yukarıda verilen dik üçgensel bölgede,
|AB| = 3 cm ve |BC| = 6 cm
olduğuna göre,
ABC dik üçgensel bölgesinin alanı kaç cm^2 dir?

A) 3 cm^2 B) 6 cm^2
C) 9 cm^2 D) 18 cm^2

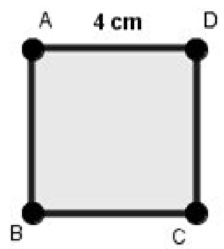
3.



Yukarıda verilen üçgensel bölgede,
[AH] ⊥ [HC], |AH| = 2 cm ve |BC| = 5 cm
olduğuna göre,
ABC üçgensel bölgesinin alanı kaç cm^2 dir?

A) 2 cm^2 B) 5 cm^2
C) 7 cm^2 D) 10 cm^2

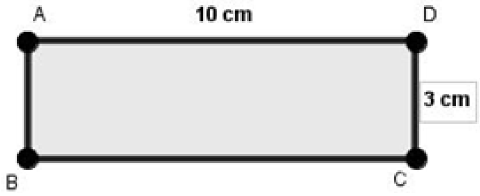
4.



Yanda verilen karesel bölgede,
|AD| = 4 cm
olduğuna göre,
ABCD karesel bölgesinin alanı kaç cm^2 dir?

A) 4 cm^2 B) 8 cm^2
C) 12 cm^2 D) 16 cm^2

5.



Yukarıda verilen dikdörtgensel bölgede,

|AB| = 10 cm ve |CD| = 3 cm

olduğuna göre,

A(ABCD) kaç cm^2 dir?

A) 13 cm^2 B) 15 cm^2

C) 26 cm^2 D) 30 cm^2

6.

Yukarıdaki şekilde verilen ABCD dikdörtgensel bölgesinde,

|DC| = 5 m ve Çevre(ABCD) = 34 m

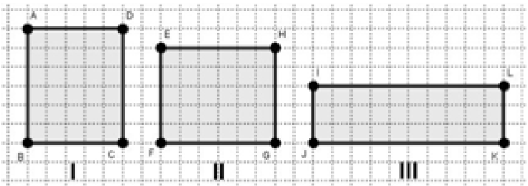
olduğuna göre,

[BC] kenarının uzunluğu kaç m dir?

A) 5 m B) 12 m

C) 17 m D) 29 m

7. Aşağıda verilen dörtgensel bölgelerin alanları birbirine eşit ve 30 br^2 dir.

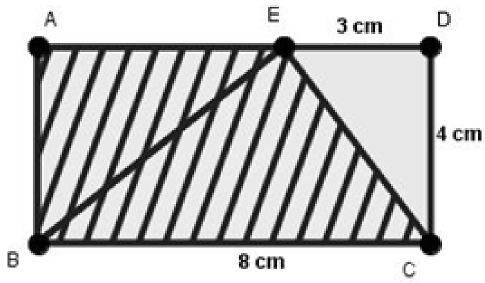


Bu dörtgensel bölgelerin çevrelerinin büyüklük sıralaması aşağıdakilerden hangisidir?

A) III > II = I B) III > II > I

C) II > III > I D) I = II > III

8.

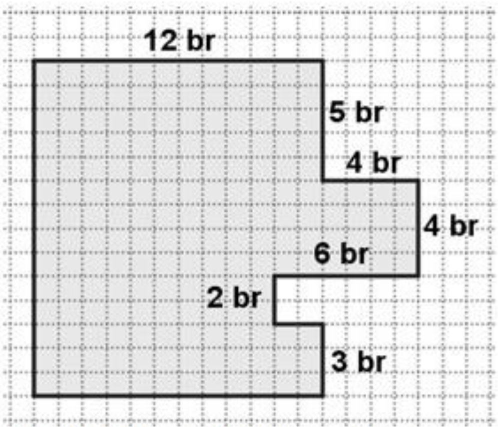


Yukarıda verilen ABCD dikdörtgensel bölgesinde taralı kısımların alanı toplamı kaç cm^2 dir?

A) 12 cm^2 B) 22 cm^2

C) 26 cm^2 D) 36 cm^2

9.

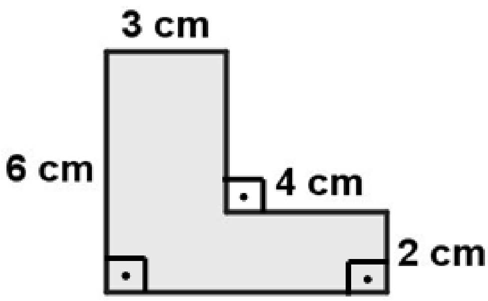


Yukarıda verilen şeklin çevre uzunluğu kaç birimdir?

A) 48 br B) 56 br

C) 64 br D) 72 br

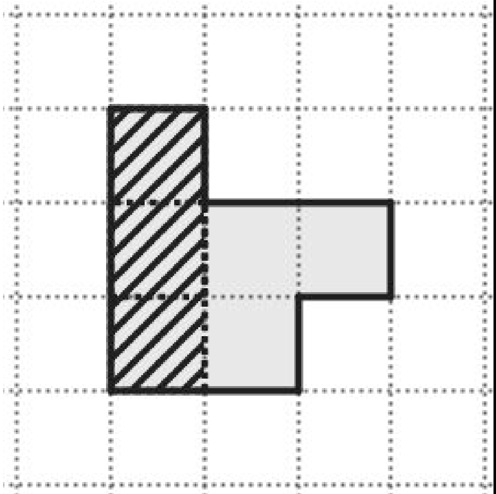
10.



Yukarıda verilen şeklin alanı kaç cm² dir?

A) 26 cm²
B) 22 cm²
C) 18 cm²
D) 12 cm²

11.

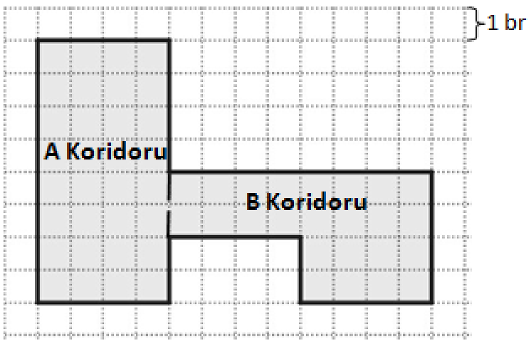


Yukarıda verilen şekil birbirine eş karesel bölgelerden oluşmuştur.

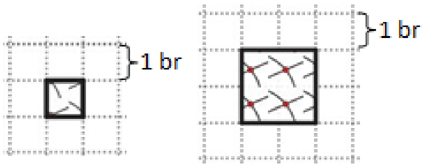
Taralı kısmın çevresi 40 cm olduğuna göre, Şeklin toplam alanı kaç cm² dir?

A) 150 cm²
B) 120 cm²
C) 80 cm²
D) 40 cm²

12. 13. ve 14. soruları aşağıdaki şekle göre cevaplayınız.



Ömer, yukarıda çizim taslağı verilen evinin koridorunun tabanını karolarla kaplamak istemektedir. Bu işlemi gerçekleştirmek için seçtiği karolar aşağıda verilmiştir.



Bu karolardan Ömer'e maliyeti,
I numaralı karonun tanesi 2 TL, II numaralı karonun tanesi ise 5 TL dir.

12. Ömer, I numaralı karolarla A ve B koridorlarının tamamını kaç TL ye kaplayabilir?

A) 56 TL
B) 74 TL
C) 96 TL
D) 112 TL

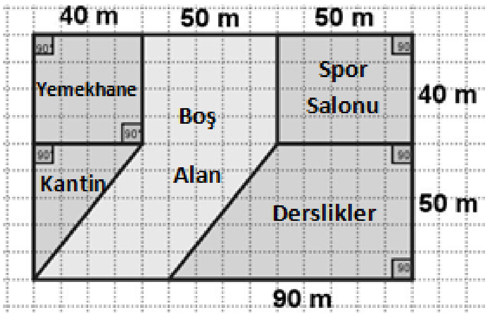
13. Ömer, II numaralı karolarla A ve B koridorlarının tamamını kaç TL ye kaplayabilir?

A) 50 TL
B) 70 TL
C) 90 TL
D) 110 TL

14. Eğer Ömer A koridorunu I numaralı karo ile ve B koridorunu da II numaralı karo ile kaplarsa toplam ne kadar TL harcamış olur?

A) 64 TL
B) 82 TL
C) 94 TL
D) 122 TL

15. 16. 17. ve 18. soruları aşağıdaki şekle göre cevaplayınız.



Yukarıda bir okulun yerleşim planının çizim taslağı verilmiştir.

15. Dersliklerin kapladığı alan kaç m^2 dir?

A) 1400 m^2 B) 2250 m^2
C) 3500 m^2 D) 4500m^2

16. Spor Salonunun kapladığı alan kaç m^2 dir?

A) 400 m^2 B) 600 m^2
C) 1000 m^2 D) 2000 m^2

17. Boş alanın 500 m^2 lik kısmı ağaçlandırılacaktır. Buna göre, ağaçlandırmadan sonra kalan boş arazinin alanı kaç m^2 dir?

A) 4000 m^2 B) 2500 m^2
C) 2000 m^2 D) 1000 m^2

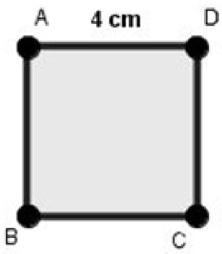
18. Kantin ve Yemekhanenin kapladığı toplam alan kaç m^2 dir?

A) 1600 m^2 B) 2600 m^2
C) 3600 m^2 D) 4600 m^2

APPENDIX B

FINAL VERSION OF READINESS TEST FOR AREA AND PERIMETER CONCEPTS

1.



Yanda verilen karesel bölgede,
|AD| = 4 cm
olduğuna göre,
ABCD karesel bölgesinin alanı kaç cm² dir?

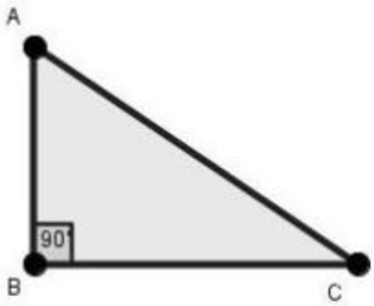
A) 4 cm² B) 8 cm²
C) 12 cm² D) 16 cm²

2.

Yukarıdaki şekilde verilen ABCD dikdörtgensel bölgesinde,
|DC| = 5 m ve Çevre(ABCD) = 34 m
olduğuna göre,
[BC] kenarının uzunluğu kaç m dir?

A) 5 m B) 12 m
C) 17 m D) 29 m

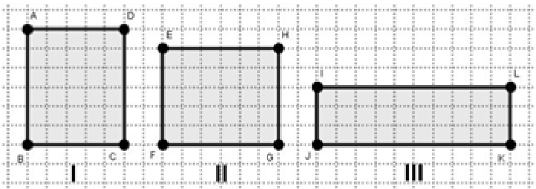
3.



Yukarıda verilen dik üçgensel bölgede,
|AB| = 3 cm ve |BC| = 6 cm
olduğuna göre,
ABC dik üçgensel bölgesinin alanı kaç cm² dir?

A) 3 cm² B) 6 cm²
C) 9 cm² D) 18 cm²

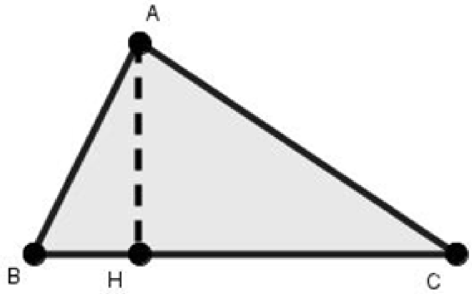
4. Aşağıda verilen dörtgensel bölgelerin alanları birbirine eşit ve 30 br² dir.



Bu dörtgensel bölgelerin çevrelerinin büyüklük sıralaması aşağıdakilerden hangisidir?

A) III > II = I B) III > II > I
C) II > III > I D) I = II > III

5.

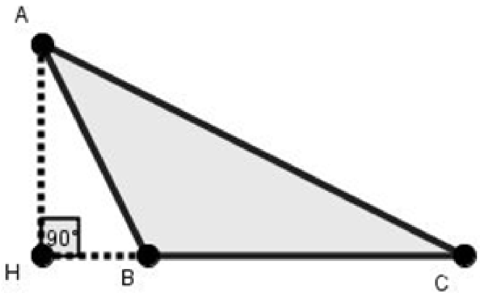


Yukarıda verilen üçgensel bölgede,
[AH] ⊥ [BC], |AH| = 2 cm ve |BC| = 4 cm olduğuna göre,

ABC üçgensel bölgesinin alanı kaç cm² dir?

A) 2 cm² B) 4 cm²
C) 6 cm² D) 8 cm²

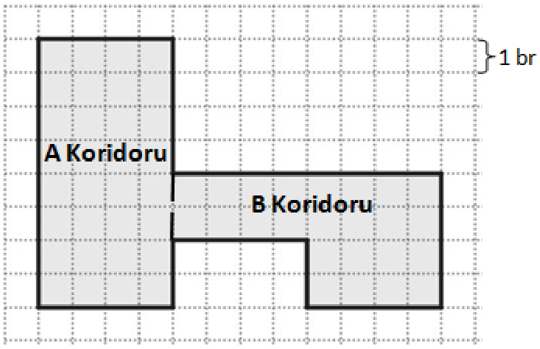
6.



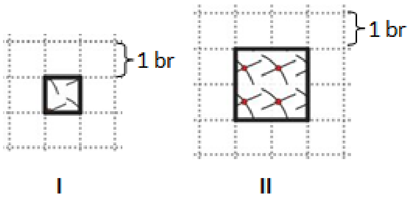
Yukarıda verilen üçgensel bölgede,
[AH] ⊥ [HC], |AH| = 2 cm ve |BC| = 5 cm olduğuna göre,
ABC üçgensel bölgesinin alanı kaç cm² dir?

A) 2 cm² B) 5 cm²
C) 7 cm² D) 10 cm²

7. 8. ve 9. soruları aşağıdaki şekle göre cevaplayınız.



Ömer, yukarıda çizim taslağı verilen evinin koridorunun tabanını karolarla kaplamak istemektedir. Bu işlemi gerçekleştirmek için seçtiği karolar aşağıda verilmiştir.



Bu karoların Ömer’e maliyeti,
I numaralı karonun tanesi 2 TL, II numaralı karonun tanesi ise 5 TL dir.

7. Ömer, I numaralı karolarla A ve B koridorlarının tamamını kaç TL ye kaplayabilir?

A) 56 TL B) 74 TL
C) 96 TL D) 112 TL

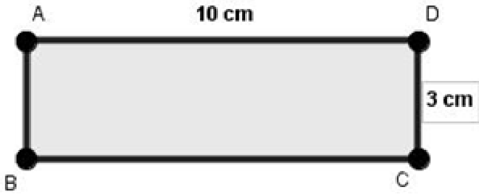
8. Ömer, II numaralı karolarla A ve B koridorlarının tamamını kaç TL ye kaplayabilir?

A) 50 TL B) 70 TL
C) 90 TL D) 110 TL

9. Eğer Ömer A koridorunu I numaralı karo ile ve B koridorunu da II numaralı karo ile kaplarsa toplam ne kadar TL harcamış olur?

A) 64 TL B) 82 TL
C) 94 TL D) 122 TL

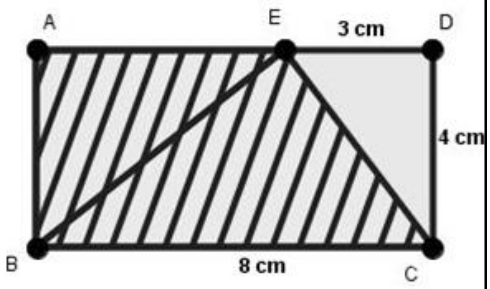
10.



Yukarıda verilen dikdörtgensel bölgede,
|AD| = 10 cm ve |CD| = 3 cm
olduğuna göre,
A(ABCD) kaç cm² dir?

A) 13 cm² B) 15 cm²
C) 26 cm² D) 30 cm²

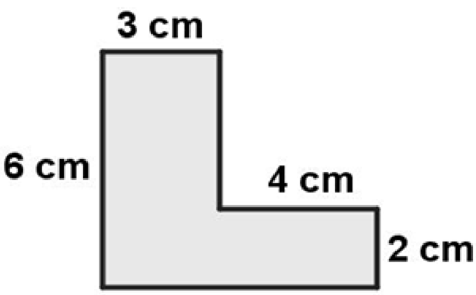
11.



Yukarıda verilen ABCD dikdörtgensel bölgesinde taralı kısımların alanı toplamı kaç cm² dir?

A) 12 cm² B) 22 cm²
C) 26 cm² D) 36 cm²

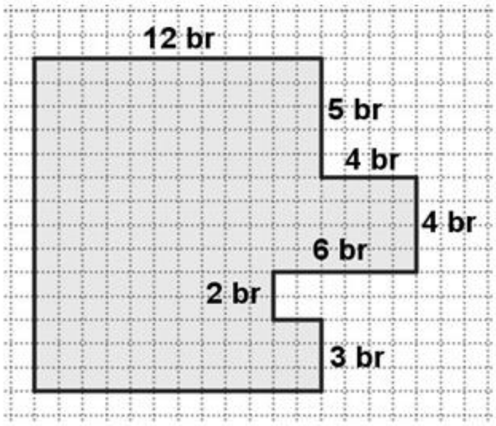
12.



Yukarıda verilen şeklin alanı kaç cm² dir?

A) 26 cm² B) 22 cm²
C) 18 cm² D) 12 cm²

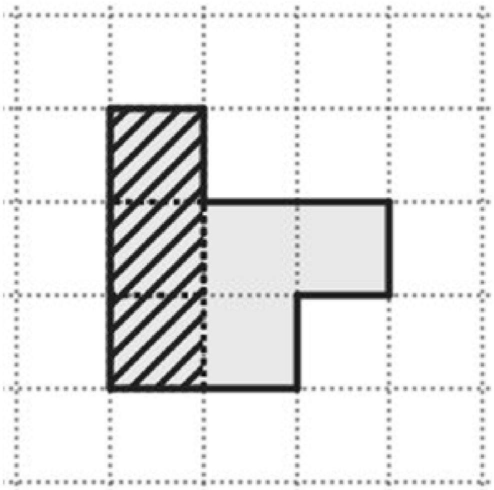
13.



Yukarıda verilen şeklin çevre uzunluğu kaç birimdir?

A) 48 br B) 56 br
C) 64 br D) 72 br

14.

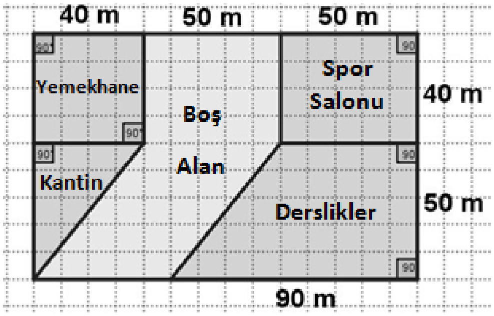


Yukarıda verilen şekil birbirine eş karesel bölgelerden oluşmuştur.

Taralı kısmın çevresi 40 cm olduğuna göre,
Şeklin toplam alanı kaç cm² dir?

A) 150 cm² B) 120 cm²
C) 80 cm² D) 40 cm²

15. 16. 17. ve 18. soruları aşağıdaki şekle göre cevaplayınız.



Yukarıda bir okulun yerleşim planının çizim taslağı verilmiştir.

15. Dersliklerin kapladığı alan kaç m² dir?

A) 1400 m² B) 2250 m²
C) 3500 m² D) 4500m²

16. Spor Salonunun kapladığı alan kaç m² dir?

A) 400 m² B) 600 m²
C) 1000 m² D) 2000 m²

17. Boş alanın 500 m² lik kısmı ağaçlandırılacaktır. Buna göre, ağaçlandırmadan sonra kalan boş arazinin alanı kaç m² dir?

A) 4000 m² B) 2500 m²
C) 2000 m² D) 1000 m²

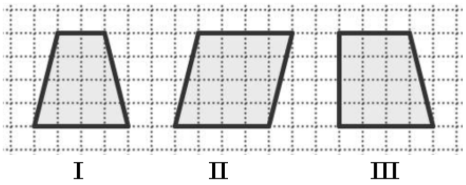
18. Kantin ve Yemekhanenin kapladığı toplam alan kaç m² dir?

A) 1600 m² B) 2600 m²
C) 3600 m² D) 4600 m²

APPENDIX C

FORMER VERSION OF AREA OF QUADRILATERALS ACHIEVEMENT TEST

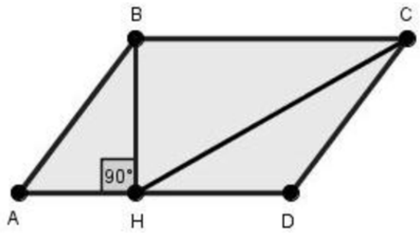
1.



Yukarıda kareli kâğıda çizilmiş olan I, II ve III numaralı dörtgensel bölgelerin alanlarına göre sıralanışı aşağıdakilerden hangisidir?

A) I < II < III B) I < III < II
C) II < III < I D) III < II < I

2.



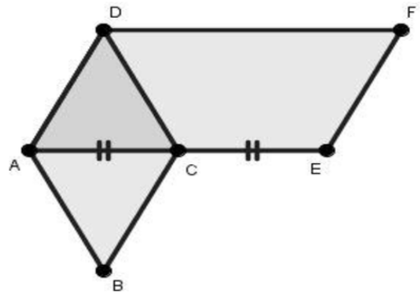
Yukarıdaki şekilde, ABCD dörtgensel bölgesi bir paralelkenarsal bölge ve [BH] ⊥ [AD] dir.

A(ABCD) = 36 cm^2 ve A(CHD) = 12 cm^2 olduğuna göre,

A(ABH) kaç cm^2 dir?

A) 3 cm^2 B) 9 cm^2
C) 6 cm^2 D) 12 cm^2

3.



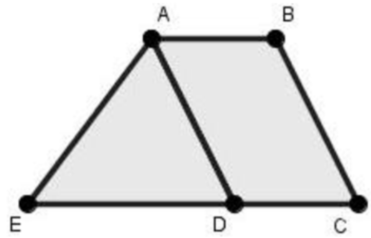
Yukarıdaki şekilde ABCD bir eşkenar dörtgensel bölge ve AEFD bir paralelkenarsal bölgedir.

A(ABCD) = 30 br^2 ve |AC| = |CE| olduğuna göre,

AEFD paralelkenarsal bölgesinin alanı kaç br^2 dir?

A) 30 br^2 B) 40 br^2
C) 45 br^2 D) 60 br^2

4.



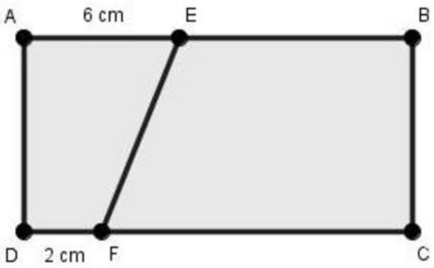
Yukarıdaki şekilde ABCD dörtgensel bölgesi bir paralelkenarsal bölge ve ABCE bir yamuksal bölgedir.

|ED| = 5 cm , |DC| = 3 cm ve A(ABCD) = 12 cm^2 olduğuna göre,

A(ABCE) kaç cm^2 dir?

A) 12 cm^2 B) 34 cm^2
C) 22 cm^2 D) 44 cm^2

5.



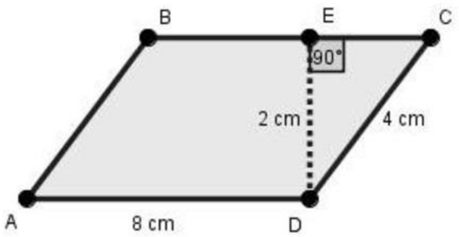
Yukarıdaki şekilde ABCD bir dikdörtgensel bölge ve |AE| = 6 cm , |DF| = 2cm dir.

|AB| = 2|AD| ve A(AEFD) = 40 cm^2 olduğuna göre,

A(BEFC) kaç cm^2 dir?

A) 160 cm^2 B) 60 cm^2
C) 80 cm^2 D) 40 cm^2

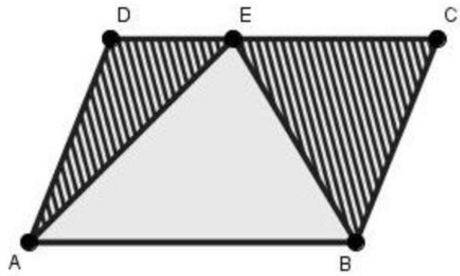
6.



ABCD paralelkenarsal bölgesinde |DC| kenarına ait yükseklik kaç cm dir?

A) 1 cm B) 3 cm
C) 2 cm D) 4 cm

7.



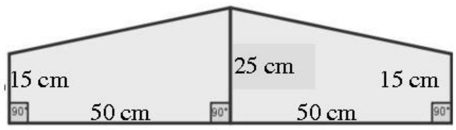
Yukarıdaki ABCD paralelkenarsal bölgesinde belirtilen taralı bölgelerin toplam alanı;

A(ADE) + A(BEC) = 120 cm^2 olduğuna göre,

A(ABCD) kaç cm^2 dir?

A) 60 cm^2 B) 120 cm^2
C) 90 cm^2 D) 240 cm^2

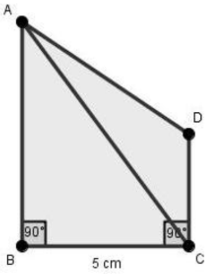
8. Şenol ve Bilal maket uçak yapacaklardır.



Yukarıdaki şekilde, bu maket uçağın kanadının ölçüleri gösterilmiştir. Kanadın yapılacağı malzemenin 1000 cm^2 si 3 TL den satıldığına göre, bu kanat için ödenecek tutar kaç TL dir?

A) 6 TL B) 18 TL
C) 3 TL D) 12 TL

9.

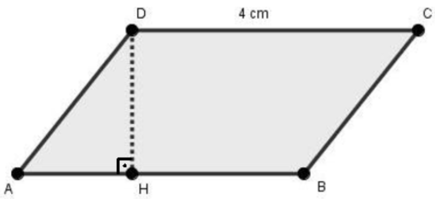


Yandaki ABCD dik yamuksal bölgesinde
|BC| = 5 cm
|AB| = 2|CD|
A(ABC) = 10 cm^2
olduğuna göre,

A(ABCD) kaç cm^2 dir?

A) 60 cm^2 B) 30 cm^2
C) 45 cm^2 D) 15 cm^2

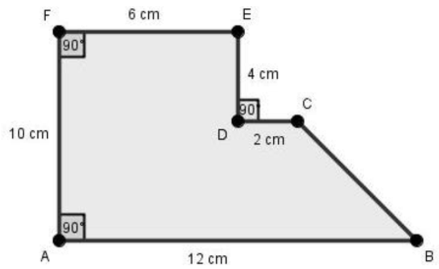
10.



Alanı 18 cm^2 olan bir paralelkenarsal bölgesinin tabanı 4 cm uzunluğunda olduğuna göre bu tabana ait yüksekliği kaç cm dir?

A) 4,5 cm B) 3 cm
C) 2,5 cm D) 2 cm

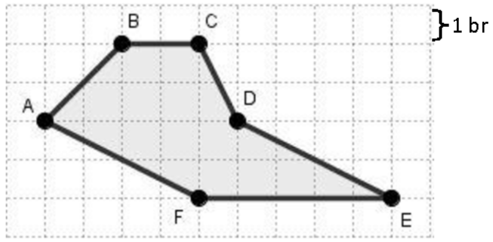
11.



Yukarıdaki şeklin alanı kaç cm^2 dir?

A) 44 cm^2 B) 84 cm^2
C) 60 cm^2 D) 90 cm^2

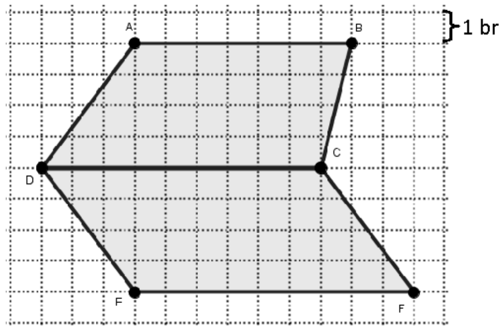
12.



Yukarıda kareli kâğıda çizilen çokgensel bölgenin alanı kaç br^2 dir?

A) 20 br^2 B) 17 br^2
C) 18 br^2 D) 19 br^2

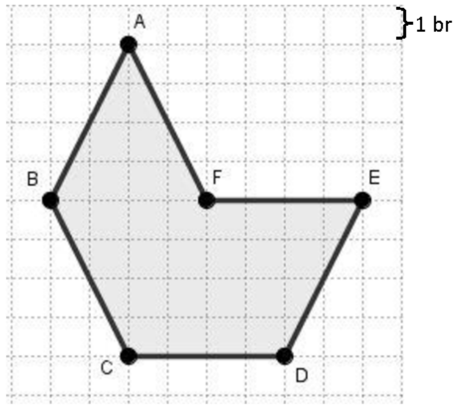
13.



Şekildeki dörtgensel bölgelerin alanları toplamı kaç br^2 dir?

A) 72 br^2 B) 68 br^2
C) 64 br^2 D) 56 br^2

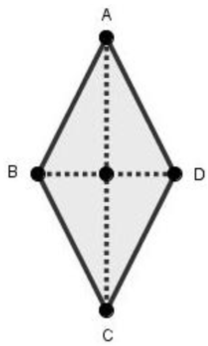
14.



Yukarıdaki çokgensel bölgenin alanı kaç br^2 dir?

A) 64 br^2 B) 36 br^2
C) 48 br^2 D) 32 br^2

15.

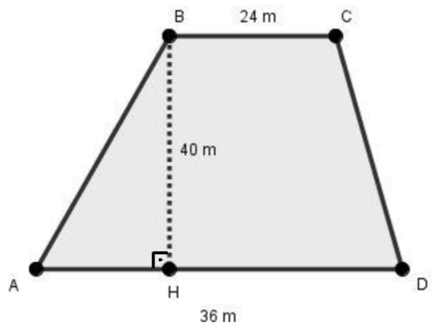


Bir köşegeninin uzunluğu diğer köşegeninin uzunluğunun 2 katına eşit olan bir eşkenar dörtgensel bölgenin alanı 64 cm^2 dir.

Buna göre, bu eşkenar dörtgensel bölgenin köşegen uzunlukları farkı kaç cm dir?

A) 16 cm B) 4 cm
C) 8 cm D) 2 cm

16.

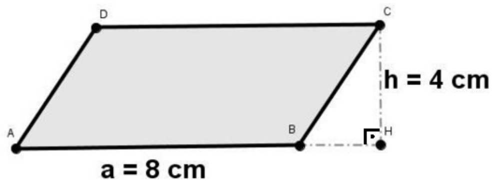


Yukarıdaki şekilde;
|BC| = 24 m , |AD| = 36 m , |BH| = 40 m ve [BH]⊥[AD] olduğuna göre,

A(ABCD) kaç m^2 dir?

A) 600 m^2 B) 1800 m^2
C) 1200 m^2 D) 2400 m^2

17.

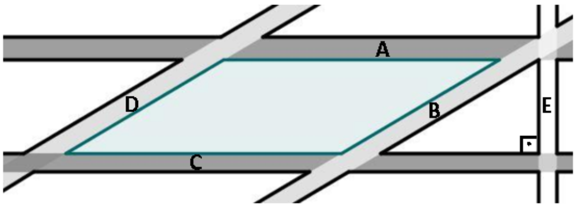


Şekilde verilen paralelkenarsal bölgede,
|CH| = 4 cm, |AB| = 8 cm ve [CH]⊥[AH] olduğuna göre,

Bu paralel kenarsal bölgenin alanı kaç cm^2 dir?

A) 12 cm^2 B) 32 cm^2
C) 16 cm^2 D) 36 cm^2

18.



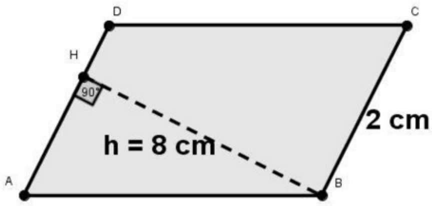
Yukarıda bir mahalleden geçen yollar gösterilmiştir.
Bu yollardan,
'A' Yolu ve 'C' Yolu birbirine paralel,
'B' Yolu ve 'D' Yolu birbirine paralel ve
'E' Yolu ise 'A' Yolu ve 'C' Yoluna dik olarak geçmektedir.
'A', 'B', 'C' ve 'D' yolları arasında kalan araziye bir çocuk parkı yapılmak istenmektedir.

'D' ve 'B' yolları arası 'A' yolu üzerinden 400 m ve 'A' ve 'C' yolları arası 'E' yolu üzerinden 100 m ise

çocuk parkı yapılmak istenilen arazi kaç m^2 dir?

A) 20000 m^2 B) 40000 m^2
C) 30000 m^2 D) 50000 m^2

19.

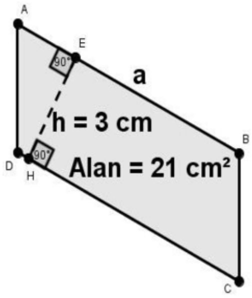


Şekilde verilen paralelkenarsal bölgede,
|BH| = 8 cm ve |BC| = 2 cm olduğuna göre,

A(ABCD) kaç cm² dir?

A) 4 cm B) 8 cm
C) 12 cm D) 16 cm

20.



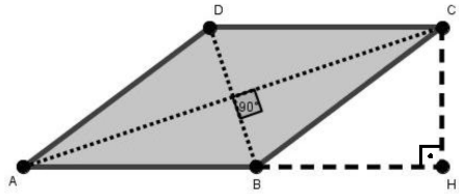
Yandaki paralelkenarsal bölgede,

|EH| = 3 cm ve A(ABCD) = 21 cm^2 olduğuna göre;

|AB| kaç cm dir?

A) 3 cm B) 7 cm
C) 6 cm D) 10 cm

21.

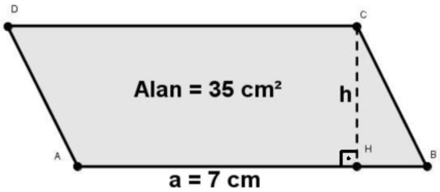


Yukarıda verilen eşkenar dörtgensel bölgede,

|DB| = 12 br , |AC| = 16 br , |AB| = 10 br ve [CH]⊥[AH] ise;
|CH| kaç br dir?

A) 19,2 br B) 14,4 br
C) 9,6 br D) 4,8 br

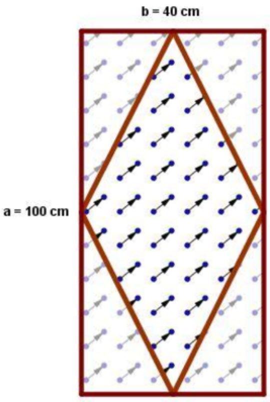
22.



Şekilde verilen paralelkenarsal bölgenin, alanı 35 cm² ve yüksekliğe ait kenarın uzunluğu 7 cm ise yüksekliği kaç cm dir?

A) 4 cm B) 7 cm
C) 5 cm D) 10 cm

23.



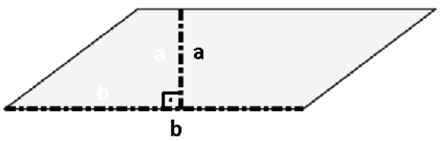
Ayşe, hafta sonu arkadaşlarıyla birlikte uçurtma uçuracaktır.

Uçurtma yapmak için dikdörtgen şeklindeki renkli bir karton almıştır. Bu kartondan yanda gösterildiği gibi eşkenar dörtgensel bir bölge kesmesi gerekmektedir.

Ayşe'nin yapacağı bu uçurtmanın alan kaç cm^2 dir?

A) $1000\ cm^2$ B) $3000\ cm^2$
C) $2000\ cm^2$ D) $4000\ cm^2$

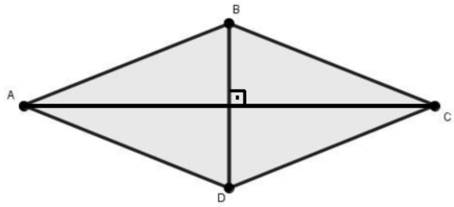
24. Ahmet'in paralelkenarsal bölge şeklinde bir tarlası vardır.



Ahmet bu tarlayı sulamak için şekilde gösterilen ve birbirine dik olarak geçen 'a' ve 'b' kanallarını yapmıştır.
Bu kanallardan,
'a' kanalı 200 metre,
'b' kanalı 400 metre uzunluğunda ise,
Ahmet'in tarlasının alanı kaç metrekaredir?

A) $20000\ m^2$ B) $60000\ m^2$
C) $40000\ m^2$ D) $80000\ m^2$

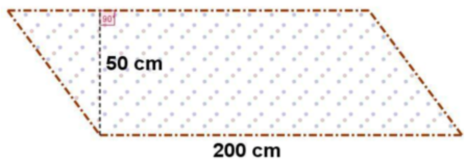
25.



Yukarıdaki eşkenar dörtgensel bölgenin alanı $90\ cm^2$ ve $|DB| = 10$ cm olduğuna göre, $|AC|$ kaç cm dir?

A) 18 cm B) 9 cm
C) 12 cm D) 6 cm

26.



Meva ve Büşra okul tiyatrosu için paralelkenarsal bölge şeklinde bir poster hazırlayacaklardır.
Bu posterin, yüksekliği 50 cm ve uzunluğu 200 cm olması gerektiğine göre, Meva ve Büşra'nın kaç cm^2 lik kâğıda ihtiyaçları vardır?

A) $10000\ cm^2$ B) $30000\ cm^2$
C) $20000\ cm^2$ D) $40000\ cm^2$

27. 20 tane birim karenin kenarları yan yana getirilerek birleştirilmesi ile oluşturulan dörtgenin çevre uzunluğu en çok kaç birim olabilir?

A) 18 br B) 42 br
C) 36 br D) 48 br

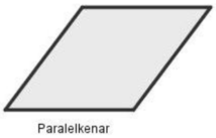
28. 160 cm uzunluğundaki bir tel ile oluşturulan dörtgensel bölgenin alanı en fazla kaç cm^2 olabilir?

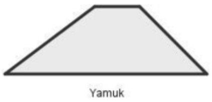
A) 3200 cm^2 B) 800 cm^2
C) 1600 cm^2 D) 400 cm^2

29. Kenar uzunlukları toplamı eşit olan aşağıdaki şekillerden hangisinin alanı diğerlerinden büyüktür?

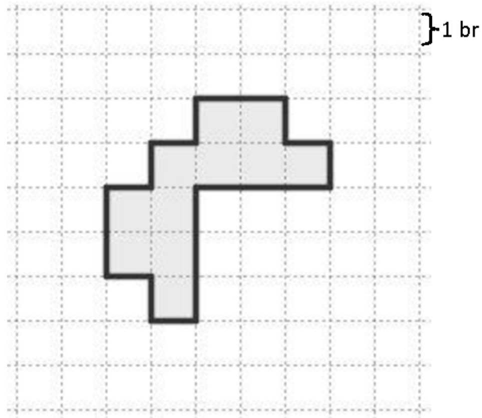
A) 

B) 

C) 

D) 

30.



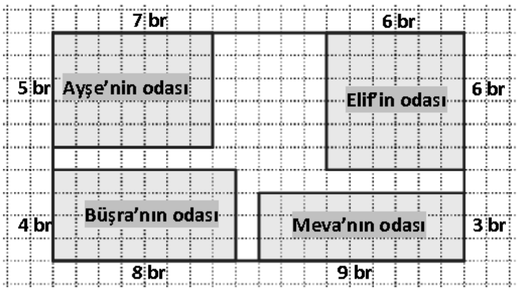
Yukarıdaki şekle yeni birim kareler eklenecektir. Şeklin çevre uzunluğu değişmeyecek şekilde en fazla kaç tane birim kare eklenebilir?

A) 12 B) 14
C) 13 D) 15

31. Altı tane birim karenin kenarları yan yana getirilerek birleştirilmesi ile oluşan şeklin çevre uzunluğu en az kaç birim olabilir?

A) 6 B) 12
C) 10 D) 14

32. Ayşe, Büşra, Elif ve Meva 4 ev arkadaşıdır. Evdeki odaların kenar uzunlukları toplamı birbirine eşit ve 24 birimdir.



Evdeki odaların kenar uzunlukları toplamı eşit olduğu için, bu 4 arkadaş odaların büyüklüklerinin de aynı olduğunu düşünmüşler. Bu yüzden, oda seçiminde bir tartışma yaşamamışlardır. Bu odalar hakkında aşağıdakilerden hangisi doğrudur?

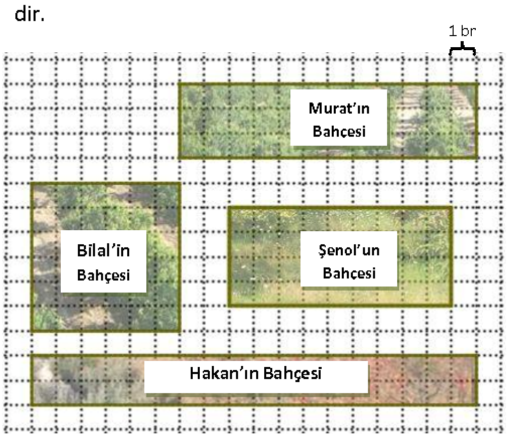
A) Odaların büyüklükleri aynıdır.

B) Sadece Ayşe ve Elif'in odaları eşit büyüklüktedir.

C) Sadece Büşra ve Meva'nın odaları eşit büyüklüktedir.

D) Bütün odaların büyüklükleri birbirinden farklıdır.

33. 4 bahçe sahibi bahçelerini tel örgü ile çevirmek istemektedir. 4 bahçenin de büyüklükleri 36 br^2 dir.



Bahçelerin büyüklükleri eşit olduğu için, bahçe sahipleri eşit uzunlukta tel örgünün bahçeleri çevirmeye yeterli olacağını düşünmüşlerdir. Bu yüzden Şenol'un bahçesinin çevresini ölçmüşler ve bu bahçenin çevresi uzunluğunda 4 adet tel örgü almışlardır. Bu tel örgü hakkında aşağıdakilerden hangisi doğrudur?

A) Bu uzunluktaki tel örgü ile bütün bahçeler çevrilebilir.

B) Bu uzunluktaki tel örgü ile sadece Bilal ve Şenol'un bahçeleri tam olarak çevrilebilir.

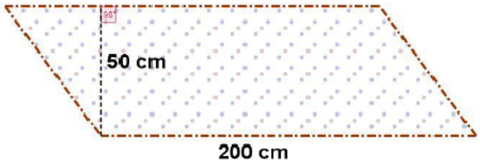
C) Bu uzunluktaki tel örgü ile sadece Şenol'un bahçesi tam olarak çevrilebilir.

D) Bu uzunluktaki tel örgü ile hiçbir bahçe tam olarak çevrilemez.

APPENDIX D

FINAL VERSION OF AREA OF QUADRILATERALS ACHIEVEMENT TEST

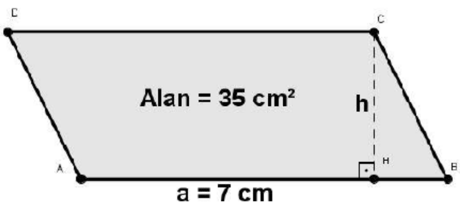
1.



Meva ve Büşra okul tiyatrosu için paralelkenarsal bölge şeklinde bir poster hazırlayacaklardır.
Bu posterin, yüksekliği 50 cm ve uzunluğu 200 cm olması gerektiğine göre, Meva ve Büşra'nın kaç cm^2 lik kağıda ihtiyaçları vardır?

A) 10000 cm^2 B) 30000 cm^2
C) 20000 cm^2 D) 40000 cm^2

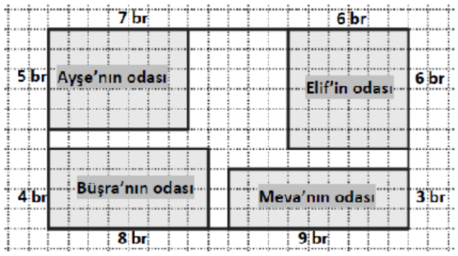
2.



Şekilde verilen paralelkenarsal bölgenin, alanı 35 cm^2 ve yüksekliğe ait kenarın uzunluğu 7 cm ise yüksekliği kaç cm dir?

A) 4 cm B) 7 cm
C) 5 cm D) 10 cm

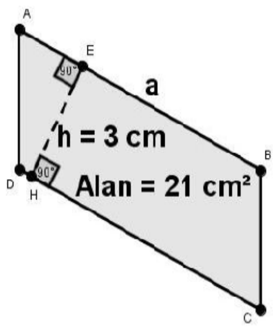
3. Ayşe, Büşra, Elif ve Meva 4 ev arkadaşıdır. Evdeki odaların kenar uzunlukları toplamı birbirine eşit ve 24 birimdir.



Evdeki odaların kenar uzunlukları toplamı eşit olduğu için, bu 4 arkadaş odaların büyüklüklerinin de aynı olduğunu düşünmüşler. Bu yüzden, oda seçiminde bir tartışma yaşamamışlardır. Bu odalar hakkında aşağıdakilerden hangisi doğrudur?

A) Odaların büyüklükleri aynıdır.
B) Sadece Ayşe ve Elif'in odaları eşit büyüklüktedir.
C) Sadece Büşra ve Meva'nın odaları eşit büyüklüktedir.
D) Bütün odaların büyüklükleri birbirinden farklıdır.

4.



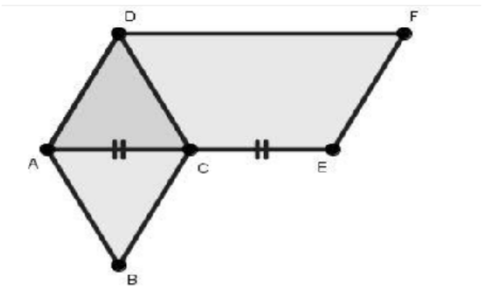
Yandaki paralelkenarsal bölgede,

|EH| = 3 cm ve
A(ABCD) = 21 cm^2
olduğuna göre;

|AB| kaç cm dir?

A) 3 cm B) 7 cm
C) 6 cm D) 10 cm

5.



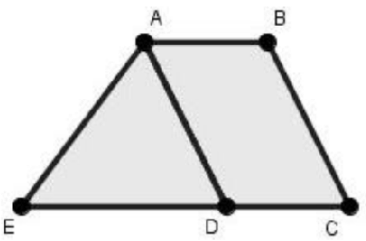
Yukarıdaki şekilde ABCD bir eşkenar dörtgensel bölge ve AEFD bir paralelkenarsal bölgedir.

A(ABCD) = 30 br^2 ve |AC| = |CE| olduğuna göre,

AEFD paralelkenarsal bölgesinin alanı kaç br^2 dir?

A) 30 br^2 B) 40 br^2
C) 45 br^2 D) 60 br^2

6.



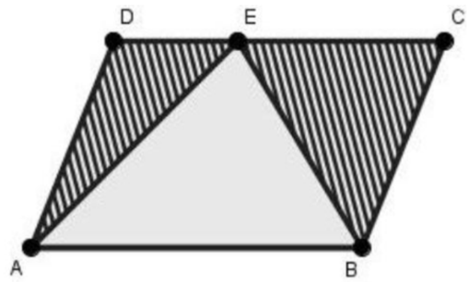
Yukarıdaki şekilde ABCD dörtgensel bölgesi bir paralelkenarsal bölge ve ABCE bir yamuksal bölgedir.

|ED| = 5 cm , |DC| = 3 cm ve A(ABCD) = 12 cm^2 olduğuna göre,

A(ABCE) kaç cm^2 dir?

A) 12 cm^2 B) 34 cm^2
C) 22 cm^2 D) 44 cm^2

7.



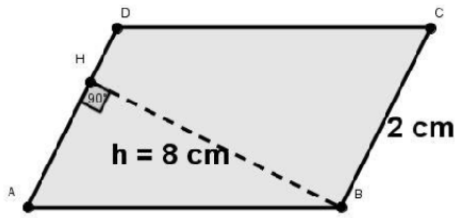
Yukarıdaki ABCD paralelkenarsal bölgesinde belirtilen taralı bölgelerin toplam alanı;

A(ADE) + A(BEC) = 120 cm^2 olduğuna göre,

A(ABCD) kaç cm^2 dir?

A) 60 cm^2 B) 120 cm^2
C) 90 cm^2 D) 240 cm^2

8.

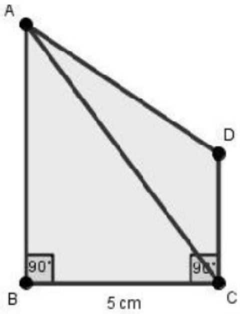


Şekilde verilen paralelkenarsal bölgede,
|BH| = 8 cm ve |BC| = 2 cm olduğuna göre,

A(ABCD) kaç cm² dir?

A) 4 cm B) 8 cm
C) 12 cm D) 16 cm

9.

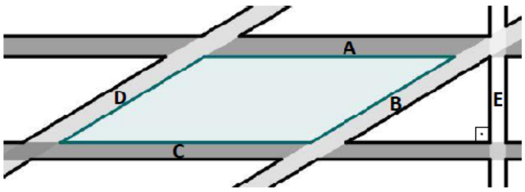


Yandaki ABCD dik yamuksal bölgesinde
$|BC| = 5$ cm
$|AB| = 2|CD|$
$A(ABC) = 10$ cm^2
olduğuna göre,

$A(ABCD)$ kaç cm^2 dir?

A) 60 cm^2 B) 30 cm^2
C) 45 cm^2 D) 15 cm^2

10.



Yukarıda bir mahalleden geçen yollar gösterilmiştir.
Bu yollardan,
'A' Yolu ve 'C' Yolu birbirine paralel,
'B' Yolu ve 'D' Yolu birbirine paralel ve
'E' Yolu ise 'A' Yolu ve 'C' Yoluna dik olarak geçmektedir.
'A', 'B', 'C' ve 'D' yolları arasında kalan araziye bir çocuk parkı yapılmak istenmektedir.

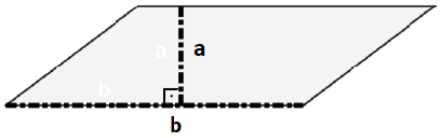
'D' ve 'B' yolları arası 'A' yolu üzerinden 400 m ve
'A' ve 'C' yolları arası 'E' yolu üzerinden 100 m ise

çocuk parkı yapılmak istenilen arazi kaç m^2 dir?

A) 20000 m^2 B) 40000 m^2
C) 30000 m^2 D) 50000 m^2

11.

Ahmet'in paralelkenarsal bölge şeklinde bir tarlası vardır.



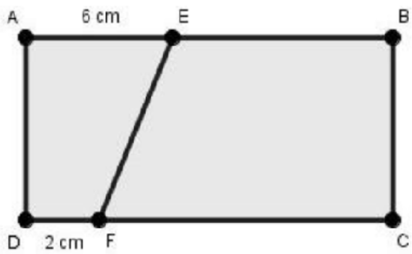
Ahmet bu tarlayı sulamak için şekilde gösterilen ve birbirine dik olarak geçen 'a' ve 'b' kanallarını yapmıştır.
Bu kanallardan,
'a' kanalı 200 metre,
'b' kanalı 400 metre uzunluğunda ise,
Ahmet'in tarlasının alanı kaç metrekaredir?

A) 20000 m^2 B) 60000 m^2
C) 40000 m^2 D) 80000 m^2

12. 160 cm uzunluğundaki bir tel ile oluşturulan dörtgensel bölgenin alanı en fazla kaç cm^2 olabilir?

A) 3200 cm^2 B) 800 cm^2
C) 1600 cm^2 D) 400 cm^2

13.



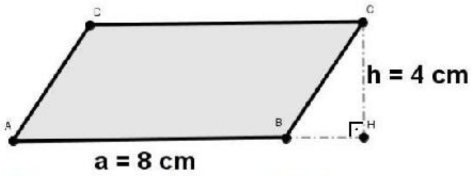
Yukarıdaki şekilde ABCD bir dikdörtgensel bölge ve $|AE| = 6$ cm , $|DF| = 2$cm dir.

$|AB| = 2|AD|$ ve $A(AEFD) = 40$ cm^2 olduğuna göre,

$A(BEFC)$ kaç cm^2 dir?

A) 160 cm^2 B) 60 cm^2
C) 80 cm^2 D) 40 cm^2

14.

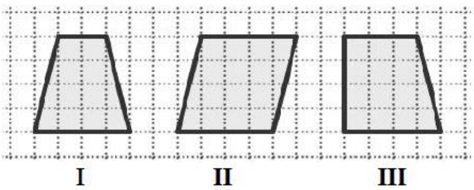


Şekilde verilen paralelkenarsal bölgede,
$|CH| = 4$ cm, $|AB| = 8$ cm ve $[CH] \perp [AH]$
olduğuna göre,

Bu paralel kenarsal bölgenin alanı kaç cm^2 dir?

A) 12 cm^2 B) 32 cm^2
C) 16 cm^2 D) 36 cm^2

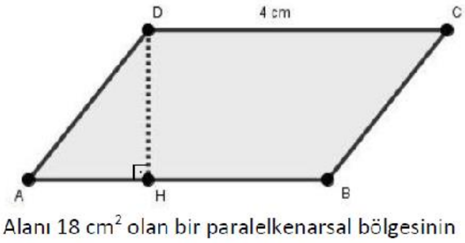
15.



Yukarıda kareli kağıda çizilmiş olan I, II ve III numaralı dörtgensel bölgelerin alanlarına göre sıralanışı aşağıdakilerden hangisidir?

A) I < II < III B) I < III < II
C) II < III < I D) III < II < I

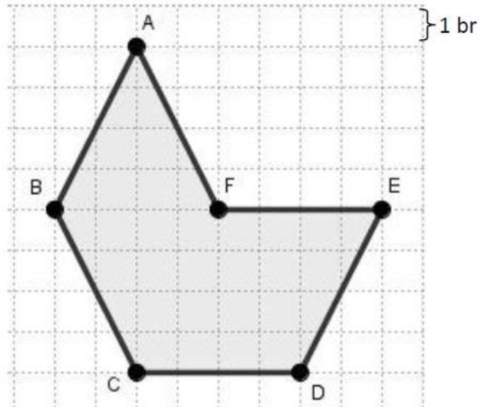
16.



Alanı 18 cm^2 olan bir paralelkenarsal bölgesinin tabanı 4 cm uzunluğunda olduğuna göre bu tabana ait yüksekliği kaç cm dir?

A) 4,5 cm B) 3 cm
C) 2,5 cm D) 2 cm

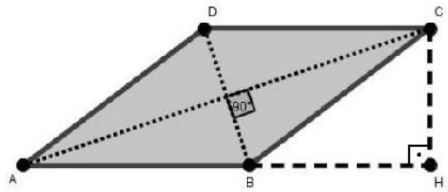
17.



Yukarıdaki çokgensel bölgenin alanı kaç br^2 dir?

A) 64 br^2 B) 36 br^2
C) 48 br^2 D) 32 br^2

18.

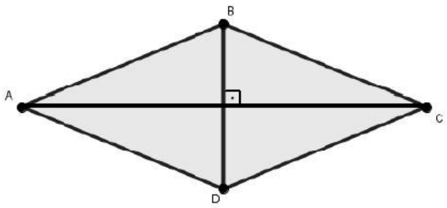


Yukarıda verilen eşkenar dörtgensel bölgede,

$|DB| = 12$ br , $|AC| = 16$ br , $|AB| = 10$ br ve $[CH] \perp [AH]$ ise;
$|CH|$ kaç br dir?

A) 19,2 br B) 14,4 br
C) 9,6 br D) 4,8 br

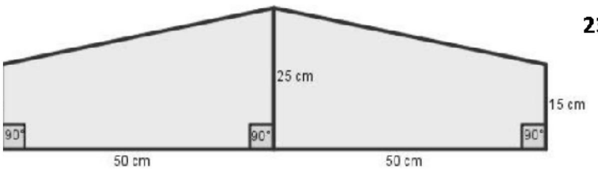
19.



Yukarıdaki eşkenar dörtgensel bölgenin alanı $90\ cm^2$ ve $|DB| = 10$ cm olduğuna göre, $|AC|$ kaç cm dir?

A) 18 cm B) 9 cm
C) 12 cm D) 6 cm

20. Şenol ve Bilal maket uçak yapacaklardır.



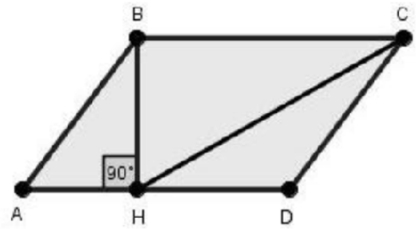
Yukarıdaki şekilde, bu maket uçağın kanadının ölçüleri gösterilmiştir. Kanadın yapılacağı malzemenin $1000\ cm^2$ si 3 TL den satıldığına göre, bu kanat için ödenecek tutar kaç TL dir?

A) 6 TL B) 18 TL
C) 3 TL D) 12 TL

21. 20 tane birim karenin kenarları yan yana getirilerek birleştirilmesi ile oluşturulan dörtgenin çevre uzunluğu en çok kaç birim olabilir?

A) 18 br B) 42 br
C) 36 br D) 48 br

22.



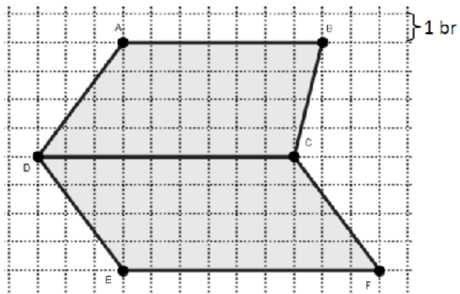
Yukarıdaki şekilde, ABCD dörtgensel bölgesi bir paralelkenarsal bölge ve $[BH] \perp [AD]$ dir.

$A(ABCD) = 36\ cm^2$ ve $A(CHD) = 12\ cm^2$ olduğuna göre,

$A(ABH)$ kaç cm^2 dir?

A) $3\ cm^2$ B) $9\ cm^2$
C) $6\ cm^2$ D) $12\ cm^2$

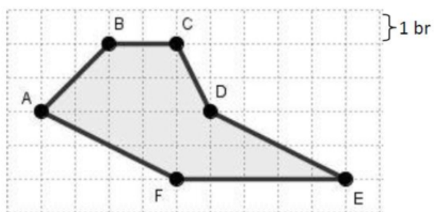
23.



Şekildeki dörtgensel bölgelerin alanları toplamı kaç br^2 dir?

A) $72\ br^2$ B) $68\ br^2$
C) $64\ br^2$ D) $56\ br^2$

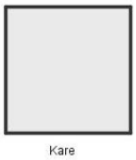
24.



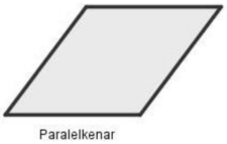
Yukarıda kareli kağıda çizilen çokgensel bölgenin alanı kaç br^2 dir?

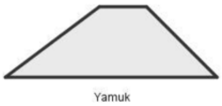
A) $20\ br^2$ B) $17\ br^2$
C) $18\ br^2$ D) $19\ br^2$

25. Kenar uzunlukları toplamı eşit olan aşağıdaki şekillerden hangisinin alanı diğerlerinden büyüktür?

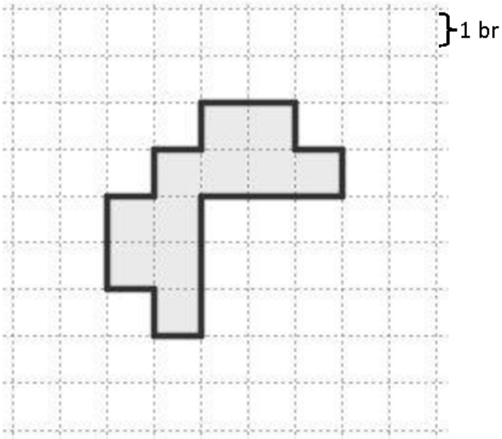
A) 

B) 

C) 

D) 

26.



Yukarıdaki şekle yeni birim kareler eklenecektir. Şeklin çevre uzunluğu değişmeyecek şekilde en fazla kaç tane birim kare eklenebilir?

A) 12 B) 14

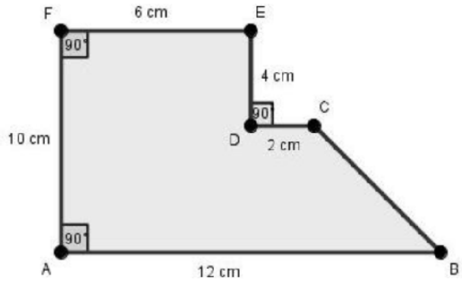
C) 13 D) 15

27. Altı tane birim karenin kenarları yan yana getirilerek birleştirilmesi ile oluşan şeklin çevre uzunluğu en az kaç birim olabilir?

A) 6 B) 12

C) 10 D) 14

28.

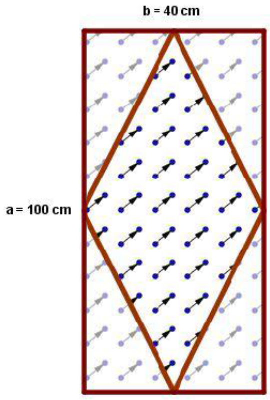


Yukarıdaki şeklin alanı kaç cm^2 dir?

A) 44 cm^2 B) 84 cm^2

C) 60 cm^2 D) 90 cm^2

29.



Ayşe, hafta sonu arkadaşlarıyla birlikte uçurtma uçuracaktır.

Uçurtma yapmak için dikdörtgen şeklindeki renkli bir karton almıştır. Bu kartondan yanda gösterildiği gibi eşkenar dörtgensel bir bölge kesmesi gerekmektedir.

Ayşe'nın yapacağı bu uçurtmanın alan kaç cm^2 dir?

A) 1000 cm^2 B) 3000 cm^2

C) 2000 cm^2 D) 4000 cm^2

APPENDIX E

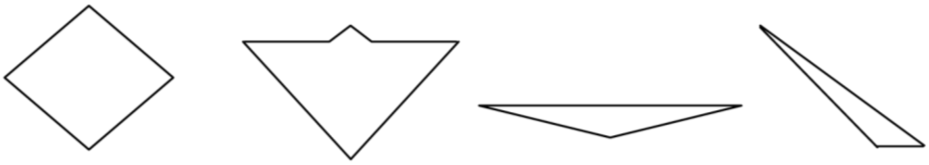
VAN HIELE GEOMETRIC THINKING LEVEL TEST

1- Aşağıdakilerden hangisi ya da hangileri karedir?

K L M

a) Yalnız K
b) Yalnız L
c) Yalnız M
d) L ve M
e) Hepsi karedir.

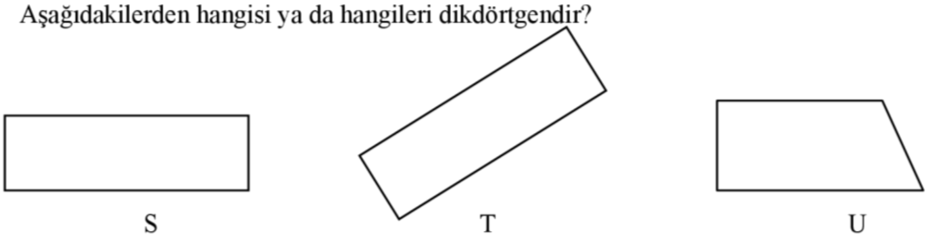
2- Aşağıdakilerden hangisi ya da hangileri üçgendir?



U V Y Z

a) Hiçbiri üçgen değildir.
b) Yalnız V
c) Yalnız Y
d) Y ve Z
e) V ve Y

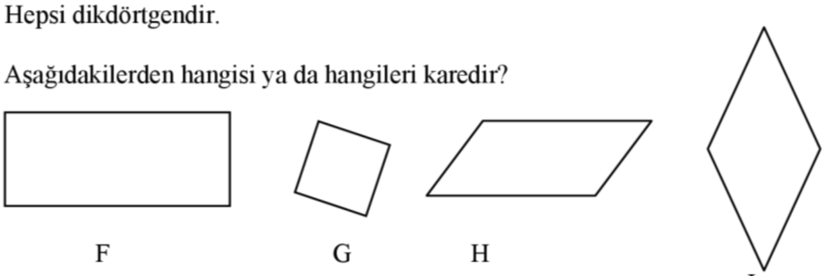
3- Aşağıdakilerden hangisi ya da hangileri dikdörtgendir?



S T U

a) Yalnız S
b) Yalnız T
c) S ve T
d) S ve U
e) Hepsi dikdörtgendir.

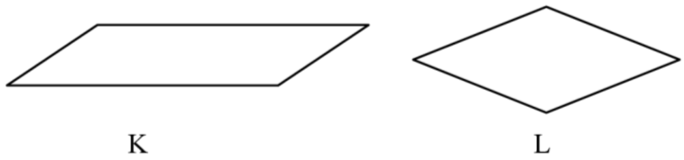
4- Aşağıdakilerden hangisi ya da hangileri karedir?



F G H I

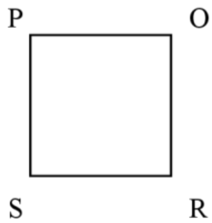
a) Hiçbiri kare değildir.
b) Yalnız G
c) F ve G
d) G ve I
e) Hepsi karedir.

5- Aşağıdakilerin hangisi ya da hangileri paralelkenardır?



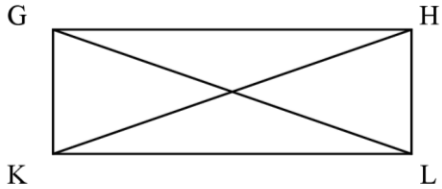
a) Yalnız K
b) Yalnız L
c) K ve M
d) Hiçbiri paralel kenar değildir.
e) Hepsi paralel kenardır.

6- PORS bir karedir.
Aşağıdakilerden hangi özellik her kare için doğrudur?



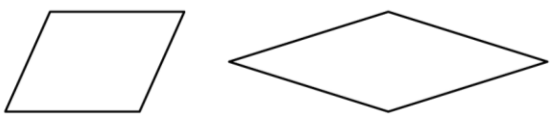
a) [PR] ve [RS] eşit uzunluktadır.
b) [OS] ve [PR] diktir.
c) [PS] ve [OR] diktir.
d) [PS] ve [OS] eşit uzunluktadır.
e) O açısı R açısından daha büyüktür.

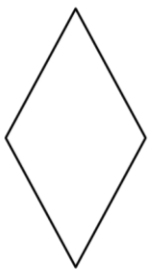
7- Bir GHJK dikdörtgeninde, [GL] ve [HK] <u>köşegendir</u>. Buna göre aşağıdakil
hangisi <u>her</u> dikdörtgen için doğrudur?



a) 4 dik açısı vardır.
b) 4 kenarı vardır.
c) Köşegenlerinin uzunlukları eşittir.
d) Karşılıklı kenarların uzunlukları eşittir.
e) Seçeneklerin hepsi her dikdörtgen için doğrudur.

8- <u>Eşkenar dörtgen</u> tüm kenar uzunlukları eşit olan, 4 kenarlı bir şekildir. Aşağıda 3
eşkenar dörtgen verilmiştir.

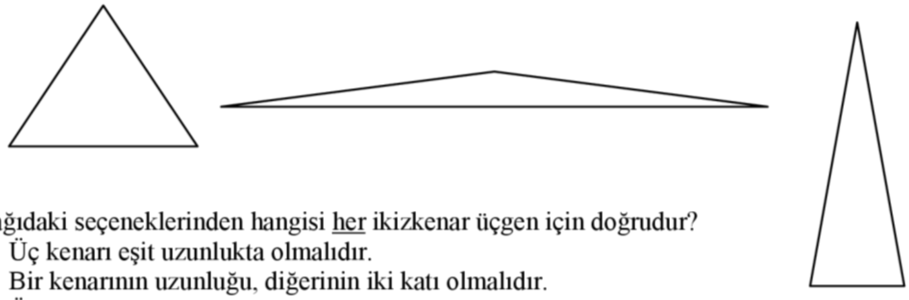




Aşağıdaki seçeneklerinden hangisi <u>her</u> eşkenar için doğru <u>değildir</u>?

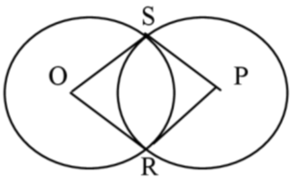
a) İki köşegenin uzunlukları eşittir.
b) Her köşegen, aynı zamanda açıortaydır.
c) Köşegenleri birbirine diktir.
d) Karşılıklı açılarının ölçüsü eşittir.
e) Seçeneklerin hepsi her eşkenar dörtgen için doğrudur.

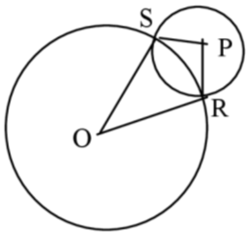
9- İkizkenar üçgen, iki kenarı eşit olan üçgendir. Aşağıda üç ikiz kenar üçgen verilmiştir.



Aşağıdaki seçeneklerinden hangisi <u>her</u> ikizkenar üçgen için doğrudur?
a) Üç kenarı eşit uzunlukta olmalıdır.
b) Bir kenarının uzunluğu, diğerinin iki katı olmalıdır.
c) Ölçüsü eşit olan en az iki açısı olmalıdır.
d) Üç açısının da ölçüsü eşit olmalıdır.
e) Seçeneklerinden hiçbiri her ikizkenar üçgen için doğru değildir.

10. Merkezleri birbirinin içinde yer almayan ve merkezleri P ve O ile adlandırılmış olan iki çember 4 kenarları PROS şeklini oluşturmak üzere R ve S noktalarında kesişirler. Aşağıda iki örnek verilmiştir.





Aşağıdaki seçeneklerinden hangisi her zaman doğru <u>değildir?</u>
a) PROS şeklinin iki kenarı eşit uzunlukta olacaktır.
b) PROS şeklinin en az iki açısının ölçüsü eşit olacaktır.
c) [PO] ve [RS] dik olacaktır.
d) P ve O açılarının ölçüleri eşit olacaktır.
e) Yukarıdaki seçeneklerin hepsi doğrudur.

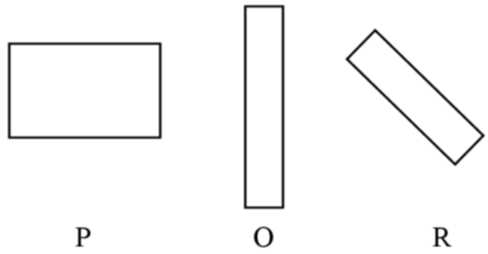
11. Önerme S: ABC üçgeninin üç kenarı eşit uzunluktadır.
Önerme T: ABC üçgeninde, B ve C açılarının ölçüleri eşittir.
Buna göre aşağıdakilerden hangisi doğrudur?

a) S ve T önermeleri ikisi de aynı anda doğru olamaz.
b) Eğer S doğruysa, T de doğrudur.
c) Eğer T doğruysa, S de doğrudur.
d) Eğer S yanlışsa, T de yanlıştır.
e) Yukarıdaki seçeneklerin hiçbiri doğru değildir.

12. Önerme 1: F şekli bir dikdörtgendir.
Önerme 2: F şekli bir üçgendir.

Bu iki önermeye göre aşağıdakilerden hangisi doğrudur?
a) Eğer 1 doğruysa, 2 de doğrudur.
b) Eğer 1 yanlışsa, 2 doğrudur.
c) 1 ve 2 aynı anda doğru olamaz.
d) 1 ve 2 aynı anda yanlış olamaz.
e) Yukarı seçeneklerin hiçbiri doğru değildir.

13. Aşağıdaki şekillerden hangisi ya da hangileri dikdörtgen olarak adlandırılabilir?



a) Hepsi
b) Yalnız O
c) Yalnız R
d) P ve O
e) O ve R

14. Tüm dikdörtgenlerde olup, bazı paralelkenarlarda olmayan özellik nedir?
a) Karşılıklı kenarları eşittir.
b) Köşegenler eşittir.
c) Karşılıklı kenarlar paraleldir.
d) Karşılıklı açıları eşittir.
e) Yukarıdaki seçeneklerin hiçbiri doğru değildir.

15- Aşağıdakilerden hangisi doğrudur?
a) Dikdörtgenlerin tüm özellikleri, tüm kareler için geçerlidir.
b) Karelerin tüm özellikleri, tüm dikdörtgenler için de geçerlidir.
c) Dikdörtgenin tüm özellikleri, tüm paralel kenarlar için geçerlidir.
d) Karelerin tüm özellikleri, tüm paralel kenarlar için geçerlidir.
e) Yukarıdaki seçeneklerin hiçbiri doğru değildir.

APPENDIX F

ANALYSIS FOR PILOT STUDY OF RTAP

Item	Proportion of Correct Answers	Discrimination Index	Point Biserial Correlation Coefficient
1	0,65	0,58	0,53
2	0,80	0,43	0,52
3	0,64	0,49	0,43
4	0,83	0,36	0,45
5	0,45	0,61	0,49
6	0,78	0,48	0,43
7	0,71	0,50	0,49
8	0,37	0,52	0,45
9	0,45	0,66	0,58
10	0,37	0,61	0,54
11	0,24	0,44	0,44
12	0,57	0,72	0,58
13	0,53	0,68	0,58
14	0,57	0,61	0,53
15	0,29	0,39	0,43
16	0,69	0,64	0,53
17	0,35	0,37	0,35
18	0,40	0,41	0,38
Average	0,54	0,53	0,49

APPENDIX G

ANALYSIS FOR PILOT STUDY OF AQAT

Item	Proportion of Correct Answers	Discrimination Index	Point Biserial Correlation Coefficient
1	0,43	0,51	0,41
2	0,33	0,37	0,39
3	0,52	0,44	0,41
4	0,51	0,62	0,47
5	0,45	0,42	0,41
6	0,48	0,20	0,17
7	0,50	0,60	0,51
8	0,39	0,54	0,41
9	0,49	0,57	0,47
10	0,43	0,54	0,45
11	0,31	0,28	0,29
12	0,33	0,43	0,42
13	0,23	0,32	0,26
14	0,43	0,52	0,45
15	0,22	0,17	0,16
16	0,33	0,19	0,20
17	0,45	0,58	0,48
18	0,48	0,65	0,59
19	0,49	0,79	0,62
20	0,52	0,65	0,52
21	0,43	0,72	0,59
22	0,56	0,63	0,52
23	0,30	0,52	0,47
24	0,46	0,74	0,59
25	0,40	0,40	0,31
26	0,64	0,59	0,47
27	0,37	0,38	0,37
28	0,46	0,31	0,30
29	0,33	0,26	0,20
30	0,33	0,30	0,29
31	0,32	0,21	0,20
32	0,55	0,56	0,46
33	0,23	-0,12	-0,11
Average	0,42	0,45	0,39

APPENDIX H

STUDENT WORKSHEETS

Student Worksheet 1: Area of Parallelogram

Paralelkenarsal Bölgede Alan

Bu etkinlikte paralelkenarsal bölgenin alan bağıntısını, bilinen alan bağıntıları yardımıyla oluşturmaya çalışacağız.

"1.1. *Paralelkenar – Öğrenci.ggb*" dosyasını açınız.

Etkinliğe Hazırlık

1. Bu etkinlikte verilen ***ABCD*** paralelkenarsal bölgesinde;
   A noktası ***yukarıya*** ve ***aşağıya***,
   B ve ***C*** noktaları ise ***sağa*** ve ***sola*** hareket etmektedir.

Etkinlik

2. Aşağıdaki adımları uygulayarak gerçekleşen değişimleri gözlemleyip not alınız.
   a. ***A*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|BC| (= |DA|)					
|AB| (= |CD|)					
Yükseklik					
Çevre					
Alan					

b. ***B*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|BC| (= |DA|)					
|AB| (= |CD|)					
Yükseklik					
Çevre					
Alan					

c. ***C*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|BC| (= |DA|)					
|AB| (= |CD|)					
Yükseklik					
Çevre					
Alan					

3. Bu adımların;

a. Hangisinde paralelkenarsal bölgenin alan ölçüsünde ***bir değişim gerçekleşti***, ve sizce neden alan ölçüsü ***değişti***?

b. Hangisinde paralelkenarsal bölgenin alan ölçüsünde ***değişim olmadı***, ve sizce neden alan ölçüsü ***değişmedi***?

4. Bu etkinlikteki verileriniz ile paralelkenarsal bölge için bir alan bağıntısı oluşturunuz.

Student Worksheet 2: The Relationship between Parallelogram and Rectangle

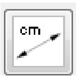
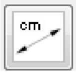
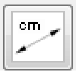
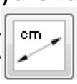
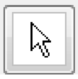
Paralelkenarsal Bölge ve Dikdörtgensel Bölge Arasındaki İlişki

Bu etkinlikte paralelkenarsal bölge ile dikdörtgensel bölgenin benzer özelliklerini bulmaya çalışacağız.

"1.2. *Paralelkenar ve Dikdörtgen.ggb*" dosyasını açınız.

Etkinliğe Hazırlık

1. ***ABCD*** paralelkenarsal bölgesinin alanını tahmin ediniz. Tahmin stratejinizi açıklayınız.

2.  ("Uzaklık ve ya Uzunluk") aracından yararlanarak paralelkenarsal bölgenin kenar uzunlukları ve yükseklik (***|EH|***) uzunluğunu bulunuz. ( aracını seçtikten sonra kenar uzunluğunu öğrenmek istediğiniz kenarı seçin.)
3.  ("Uzaklık ve ya Uzunluk") aracından yararlanarak paralelkenarsal bölgenin çevresini bulunuz. ( aracını seçtikten sonra çokgenin iç bölgesini seçin.)
4.  ("Alan") aracından yararlanarak paralelkenarsal bölgenin alanını bulunuz ( aracını seçtikten sonra çokgenin iç bölgesini seçmeniz yeterlidir.)
5. Hesaplanan Alan ve Çevre ölçülerini  aracını seçtikten sonra seçip sürükleyerek çokgen dışına taşıyınız.
6. Aşağıdaki tabloyu doldurunuz.

Paralelkenar	
	Yükseklik
	Çevre
	Alan

Etkinlik

7. ***|EH|*** yüksekliği boyunca paralelkenarsal bölgeyi kesiniz. ("***|EH|*** Boyunca Kes" butonuna tıklayarak paralelkenarsal bölgeyi iki parçaya ayırın.)
8. Elde ettiğiniz iki çokgeni bir dikdörtgen oluşturacak şekilde birleştiriniz. (Sol tarafta yer alan çokgeni fare ile taşıyabilirsiniz. Bir dikdörtgenin oluşabileceği durumlarda ekranın sağ altında "Birleştir" butonu görünecektir. Bu buton yardımıyla çokgenlerden bir dikdörtgen oluşturabilirsiniz.)
9. Oluşturduğunuz dikdörtgensel bölgenin alanını tahmin ediniz. Tahmin stratejinizi açıklayınız.

10. Oluşan dikdörtgensel bölgenin alanını ("Alan") aracından yararlanarak bulun. (aracını seçtikten sonra çokgenin iç bölgesini seçmeniz yeterlidir.)
11. ("Uzaklık ve ya Uzunluk") aracından yararlanarak dikdörtgensel bölgenin kenar uzunluklarını bulun. (aracını seçtikten sonra kenar uzunluğunu öğrenmek istediğiniz kenarı seçin.)
12. ("Uzaklık ve ya Uzunluk") aracından yararlanarak dikdörtgensel bölgenin çevresini bulunuz. (aracını seçtikten sonra çokgenin iç bölgesini seçin.)
13. Hesaplanan Alan ve Çevre ölçülerini aracını seçtikten sonra seçip sürükleyerek çokgen dışına taşıyınız.
14. Bulunan değerlerle ve ilk tablodaki bilgilerle aşağıdaki tabloyu doldurunuz.

Paralelkenar		Dikdörtgen
	Yükseklik	
	Çevre	
	Alan	

15. Oluşturulan dikdörtgensel bölgenin alanı ile paralelkenarsal bölgenin alanı arasında bir fark var mıdır? Açıklayınız.

16. Oluşturulan dikdörtgensel bölgenin yüksekliği ile paralelkenarsal bölgenin yüksekliği arasında bir fark var mıdır? Açıklayınız.

17. Oluşturulan dikdörtgensel bölgenin çevresi ile paralelkenarsal bölgenin çevresi arasında bir fark var mıdır? Açıklayınız.

18. "Bu ilişkinin gerçekleşmesi için, yükseklik paralelkenarsal bölgenin bir köşesinden geçmesi gerekmektedir" diye belirtilmiş bir ifade doğru mudur? Yoksa herhangi bir noktadan tabana dik olarak çizilen her doğru parçasında da aynı ilişkiyi görebilir miyiz? Açıklayınız.

(“Başa Dön” butonu ile ilk ekrana geri gelerek, “***H***” noktasını fare ile seçip sürükleyerek ***|EH|*** doğru parçasını taşıyabilir ve bu ifadenin doğruluğunu test edebilirsiniz.)

Student Worksheet 3: Area of Rhombus

Eşkenar Dörtgensel Bölgede Alan

Bu etkinlikte eşkenar dörtgensel bölgenin alan bağıntısını bilinen diğer alan bağıntıları yardımıyla oluşturmaya çalışacağız.

***“2.1. Eşkenar Dörtgen - Öğrenci.ggb”* dosyasını açın.**

Etkinliğe Hazırlık

5. Sağ altta yer alan “Çalıştır” butonu yardımıyla eşkenar dörtgensel bölgenin çizim aşamalarını gözlemleyiniz.
6. Şekilde ***E***, ***F***, ***G*** ve ***H*** noktaları dikdörtgensel bölgenin kenarlarının orta noktalarıdır, ***k*** ve ***j*** eşkenarsal bölgenin köşegenleridir.

Etkinlik

7. Dikdörtgensel bölgenin alan bağıntısını yazınız.

8. Şekilde verilen ***ABCD*** dikdörtgensel bölgesinin alanı nedir?

9. **“Ayır”** butonu yardımıyla dikdörtgensel bölge içine çizilen eşkenar dörtgensel bölge ile oluşan dik üçgenleri birbirinden ayırınız.
10. Ayrılan dik üçgensel bölgelerin dik kenar uzunluklarını **“Uzaklık veya Uzunluk”** ( ) aracı ile ölçün ve aşağıda yer alan tabloya yazın. (aracını seçtikten sonra kenar uzunluğunu öğrenmek istediğiniz kenarı seçin.)
11. Ayrılan üçgensel bölgelerin alanlarını **“Alan”** ( ) aracı ile ölçün ve aşağıda yer alan tabloya yazın. (aracını seçtikten sonra alanı ölçülmek istenen çokgenin iç bölgesini seçin.)

Üçgen	Kenar Uzunluğu	Kenar Uzunluğu	Alan

12. **“Döndür”** butonu yardımıyla dik üçgensel bölgeleri kendi etrafında döndürün.
13. **“Birleştir”** butonu yardımıyla dik üçgensel bölgeler ile eşkenar dörtgensel bölgeyi birleştirin.
14. Eşkenar dörtgensel bölge ile birleştirilen dik üçgenler aynı şekli mi oluşturdu? Açıklayınız.
15. Oluşan şekle göre, eşkenar dörtgensel bölgenin alanı hakkında ne diyebilirsiniz?
16. Bu etkinlikteki verileriniz ile eşkenar dörtgensel bölge için bir alan bağıntısı oluşturunuz.

Student Worksheet 4: Area Relationship between Rhombus and Parallelogram

Eşkenar Dörtgensel Bölge ve Paralelkenarsal Bölgede Alan İlişkisi

Bu etkinlikte eşkenar dörtgensel bölgenin alanı ile paralelkenarsal bölgenin alanı arasındaki ilişkiyi gözlemleyeceğiz.

***"2.2. Eşkenar Dörtgen ve Paralelkenar - Öğrenci.ggb"* dosyasını açın.**

Etkinliğe Hazırlık

1. Şekilde gördüğünüz eşkenar dörtgensel bölgede "***g***" ve "***n***" köşegenlerdir.

Etkinlik

2. Eşkenar Dörtgensel Bölgenin alanı nedir?

3. Paralelkenarsal bölgelerin alan formülü nedir?

4. **"Kopyala"** butonu yardımıyla eşkenar dörtgensel bölgemize eş bir eşkenar dörtgensel bölge oluşturun.

5. Oluşturduğumuz ikinci eşkenar dörtgensel bölgeyi **"Döndür"** butonu yardımıyla kendi etrafında döndürün.

6. İkinci eşkenar dörtgensel bölgemiz dönünce oluşan şekli gözlemleyiniz. Sizce bu şekil hangi dörtgensel bölgemizdir? Bu benzerlik eşkenar dörtgensel bölgenin hangi özelliği nedeniyle gerçekleşmiştir?

7. Oluşan şeklin alan formülü nedir?

8. Oluşan şeklin alanını bu formül yardımıyla bulunuz.

9. Bu etkinlik sonucunda eşkenar dörtgensel bölgelerle ilgili neler diyebiliriz? Bir önceki etkinliğimizde bulduğumuz alan bağıntısının yanı sıra bu etkinlikteki verileriniz ile alan bağıntısı oluşturunuz.

Student Worksheet 5: Area of Trapezoid

Yamuksal Bölgede Alan

Bu etkinlikte yamuksal bölgenin alan bağıntısını, yamuksal bölge ile etkileşime girerek oluşturmaya çalışacağız.

"3.1. *Yamuksal Bölgenin Alanı - Öğrenci.ggb*" dosyasını açınız.

Etkinliğe Hazırlık

1. Bu etkinlikte verilen ***ABCD*** yamuksal bölgesinde ***H*** noktası yukarıya ve aşağıya, ***B***, ***C*** ve ***D*** noktaları ise sağa ve sola hareket etmektedir.

Etkinlik

2. Aşağıdaki adımları uygulayarak gerçekleşen değişimleri gözlemleyip not alınız.
   a. ***B*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|AB|					
|BC|					
|CD|					
|DA|					
Yükseklik					
Çevre					
Alan					

b. ***C*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|AB|					
|BC|					
|CD|					
|DA|					
Yükseklik					
Çevre					
Alan					

c. ***D*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|AB|					
|BC|					
|CD|					
|DA|					
Yükseklik					
Çevre					
Alan					

d. ***H*** noktasını hareket ettirerek beş farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5
|AB|					
|BC|					
|CD|					
|DA|					
Yükseklik					
Çevre					
Alan					

3. Bu adımların;

   a. Hangisinde yamuksal bölgenin alan ölçüsünde bir değişim gerçekleşti, ve sizce neden alan ölçüsü değişti?

   b. Hangisinde yamuksal bölgenin alan ölçüsünde değişim olmadı, ve sizce neden alan ölçüsü değişmedi?

4. Bu etkinlikteki verileriniz ile yamuksal bölge için bir alan bağıntısı oluşturunuz.

Student Worksheet 6: Area Relationship between Trapezoid and Parallelogram

Yamuksal Bölge ve Paralelkenarsal Bölgelerde Alan İlişkisi

Bu etkinlikte yamuksal bölgenin alanı ile paralelkenarsal bölgenin alanı arasındaki ilişkiyi keşfedeceğiz.

***"3.2. Yamuk ve Paralelkenar - Öğrenci.ggb"* dosyasını açın.**

Etkinliğe Hazırlık

1. Şekilde gördüğünüz yamuksal bölgede "***a***" ve "***b***" taban kenarları, "***h***" ise yükseklitir.

Etkinlik

2. Paralelkenarsal bölgelerin alan formülü nedir?

3. **"Kopyala"** butonu yardımıyla yamuksal bölgemize eş bir yamuksal bölge oluşturun.
4. Oluşturduğumuz ikinci yamuksal bölgeyi **"Döndür"** butonu yardımıyla kendi etrafında döndürün.
5. İkinci yamuksal bölgemizi döndürdükten sonra ilk yamuksal bölgemizle bir paralelkenarsal bölge oluşturacak şekilde birleştirin. Bunun için ikinci yamuksal bölgemizi fare ile taşıyınız. Paralelkenarsal bir bölge elde ettiğiniz zaman şekillerin üst tarafında **"Birleştir"** butonu gözükecek ve bu buton yardımıyla şekilleri birleştiriniz.
6. Oluşan paralelkenarsal bölgenin taban kenarı uzunluğu nedir?

7. Oluşan paralelkenarsal bölgenin yüksekliği nedir?

8. Oluşan paralelkenarsal bölgenin alanını alan formülü yardımıyla ifade edin.

9. Bu paralelkenarsal bölgenin alanı ilk yamuksal bölgemizin alanının kaç katıdır?

10. Bu bilgiler yardımıyla yamuksal bölgenin alan bağıntısını nasıl ifade edebiliriz?

Student Worksheet 7: The Relationship between Area and Perimeter

Alan ve Çevre Arasındaki İlişki

Bu etkinlikte bir dikdörtgensel bölgenin alanı ve çevresi arasındaki ilişkiyi keşfetmeye çalışacağız.

"4.1. Alan ve Çevre İlişkisi – Öğrenci.ggb" **dosyasını açınız.**

Etkinliğe Hazırlık

1. Bu etkinlikte ***ABCD*** dikdörtgensel bölgesi verilmiştir. Bu dikdörtgensel bölgenin alanı ***36 br***^{2} dir.
2. Bu etkinlikte verilen dikdörtgensel bölgede, "***C***" noktasının hareket ettirilmesi ile alan ölçüsü değişmemektedir.

Etkinlik

3. Aşağıdaki adımları uygulayarak gerçekleşen değişimleri gözlemleyip not alınız.
   a. ***C*** noktasını hareket ettirerek altı farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5	Konum 6
|BC| (= |DA|)						
|AB| (= |CD|)						
Çevre						
Alan						

4. Bu hareketlerde değişen veriler hangileridir?

5. Alan ölçüsü değişmemesine rağmen bu hareketler sonucu kenar uzunlukları toplamında herhangi bir değişim gerçekleşti mi? Eğer gerçekleştiyse neden sizce bu değişim gerçekleşti?
6. Bulduğunuz verilere dayanarak dikdörtgensel bölgenin alanı ve kenar uzunlukları toplamı arasında nasıl bir ilişki vardır? Açıklayınız.

7. Alan ölçüsü sabit kalmak şartıyla verilen dikdörtgensel bölgelerde en büyük kenar uzunlukları toplamına ve en küçük kenar uzunluklarına sahip bölgelerin kenar uzunlukları arasında nasıl bir ilişki vardır? Açıklayınız.

Student Worksheet 8: The Relationship between Side Length and Area

Kenar Uzunluğu ve Alan Arasındaki İlişki

Bu etkinlikte bir dörtgensel bölgedeki kenar uzunluğu ve alan arasındaki ilişkiyi keşfetmeye çalışacağız.

"4.2. Kenar Uzunluğu ve Alan İlişkisi – Öğrenci.ggb" **dosyasını açınız.**

Etkinliğe Hazırlık

1. Bu etkinlikte ***ABCD*** dikdörtgensel bölgesi verilmiştir. Bu dikdörtgensel bölgenin kenar uzunlukları toplamı ***24 br*** dir.
2. Bu etkinlikte verilen dikdörtgensel bölgede, "***C***" noktasının hareket ettirilmesi ile kenar uzunlukları toplamı değişmemektedir.

Etkinlik

3. Aşağıdaki adımları uygulayarak gerçekleşen değişimleri gözlemleyip not alınız.
    a. ***C*** noktasını hareket ettirerek altı farklı konumda oluşan değerleri aşağıdaki tabloya yazınız.

	Konum 1	Konum 2	Konum 3	Konum 4	Konum 5	Konum 6
|BC| (= |DA|)						
|AB| (= |CD|)						
Çevre						
Alan						

4. Bu hareketlerde değişen veriler hangileridir?

5. Kenar uzunlukları toplamı değişmemesine rağmen bu hareketler sonucu Alan ölçüsünde herhangi bir değişim gerçekleşti mi? Eğer gerçekleştiyse neden sizce bu değişim gerçekleşti?

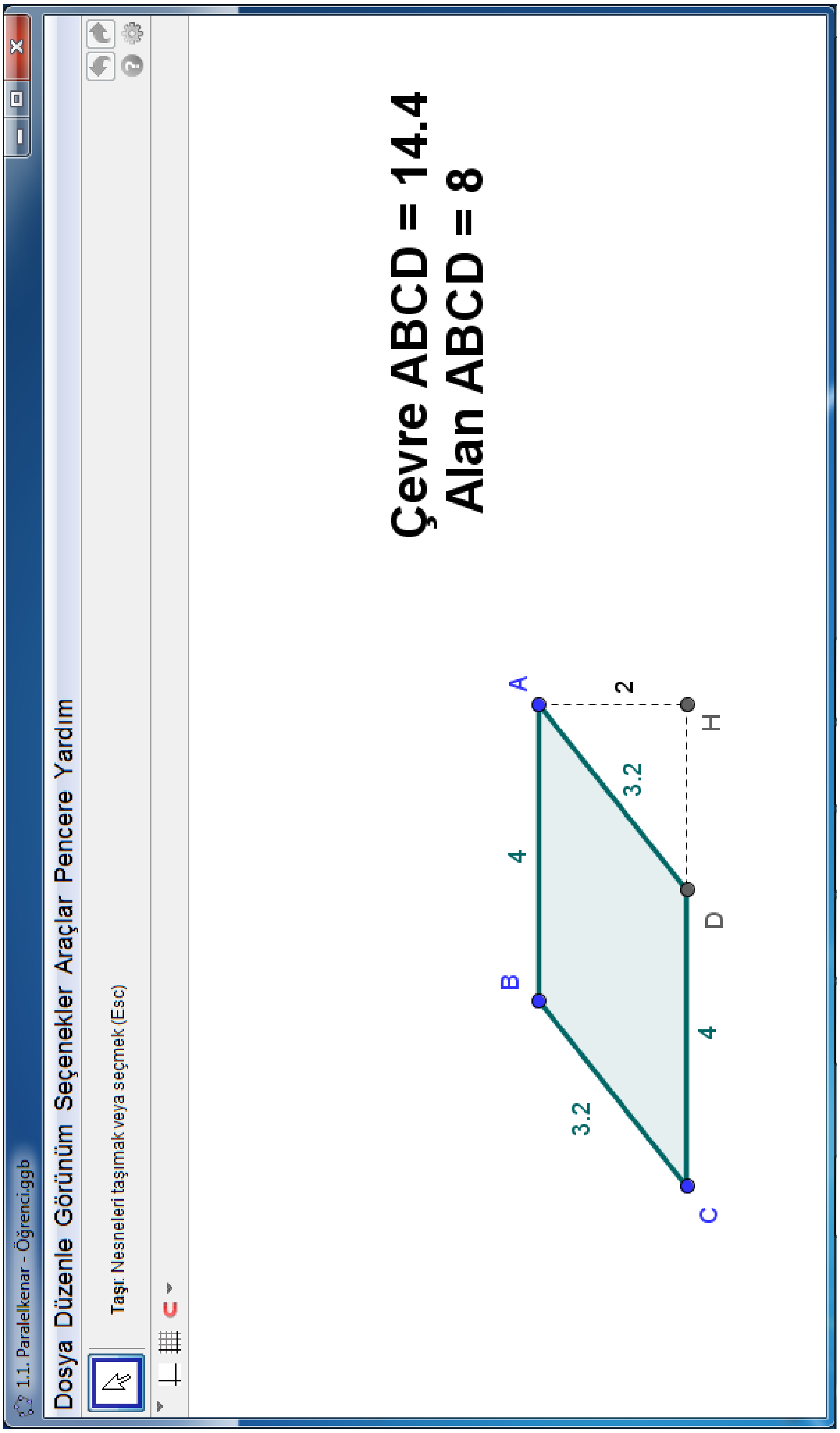
6. Bulduğunuz verilere dayanarak kenar uzunlukları ve alan ölçüsü arasında nasıl bir ilişki vardır? Açıklayınız.

7. Kenar uzunlukları toplamı sabit kalmak şartıyla verilen dikdörtgensel bölgelerde en büyük alan ölçüsüne ve en küçük alan ölçüsüne sahip bölgelerin kenar uzunlukları arasında nasıl bir ilişki vardır? Açıklayınız.

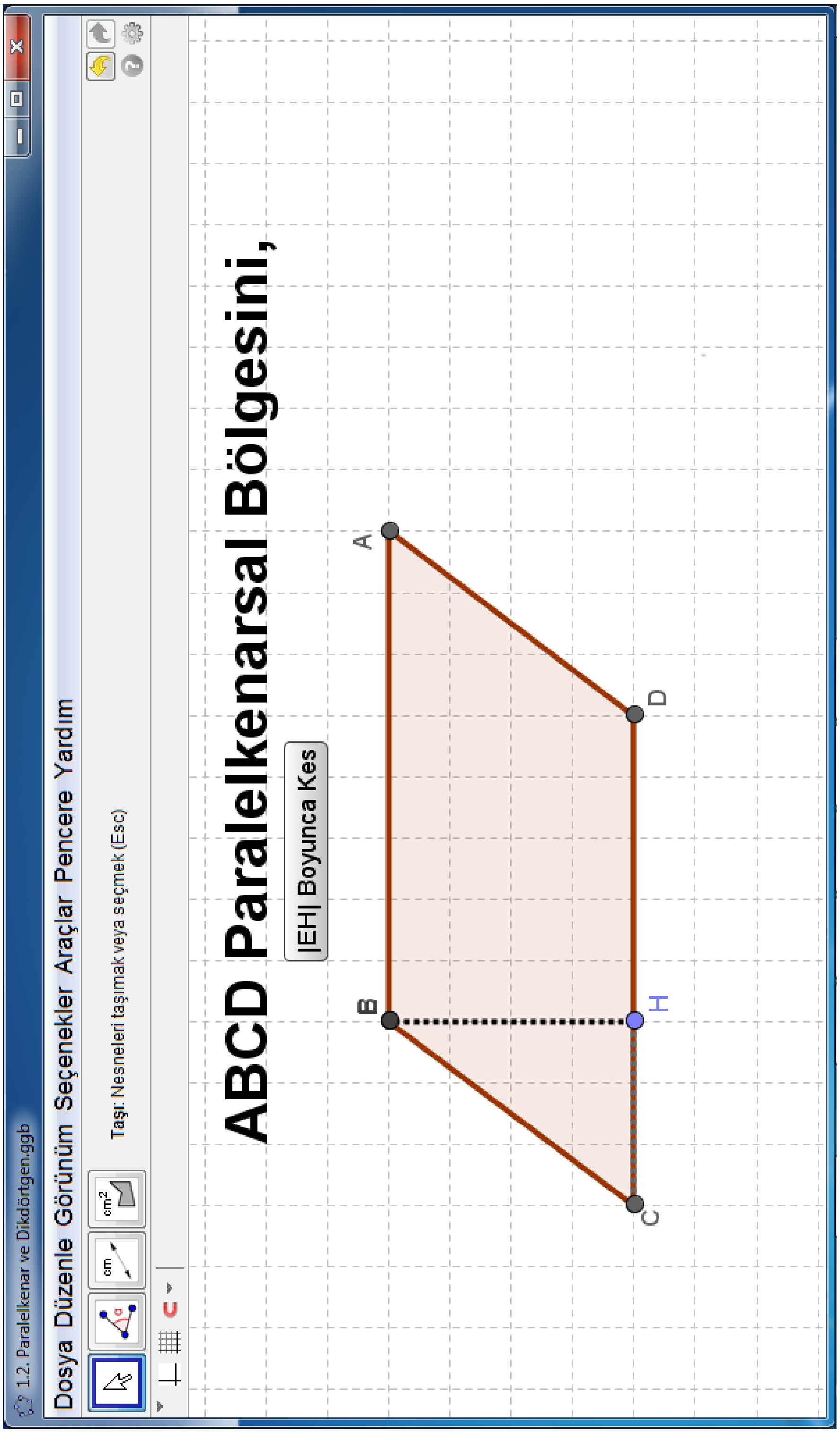
APPENDIX I

GEOGEBRA SCREEN VIEWS

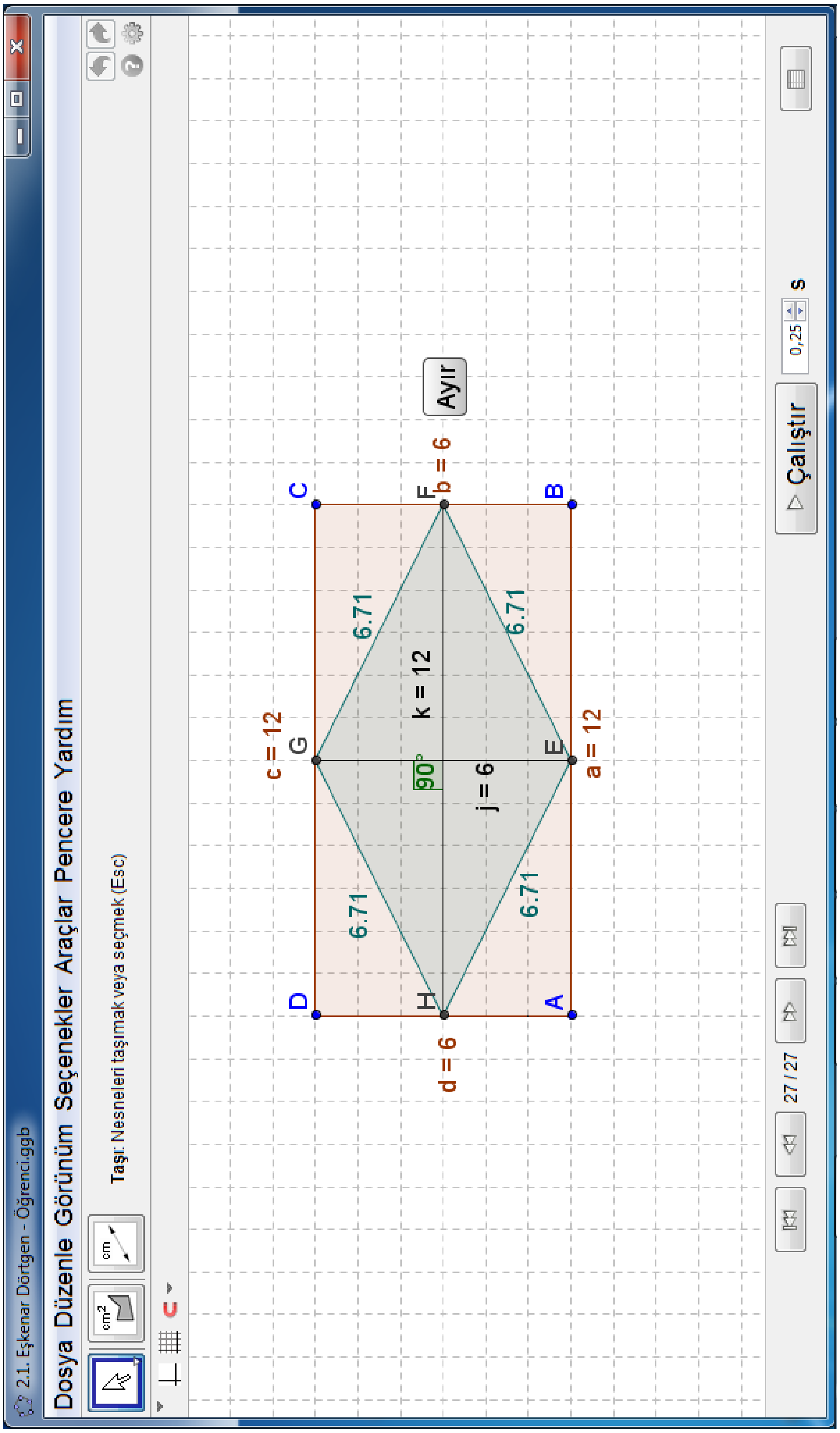
Activity 1: Area of Parallelogram



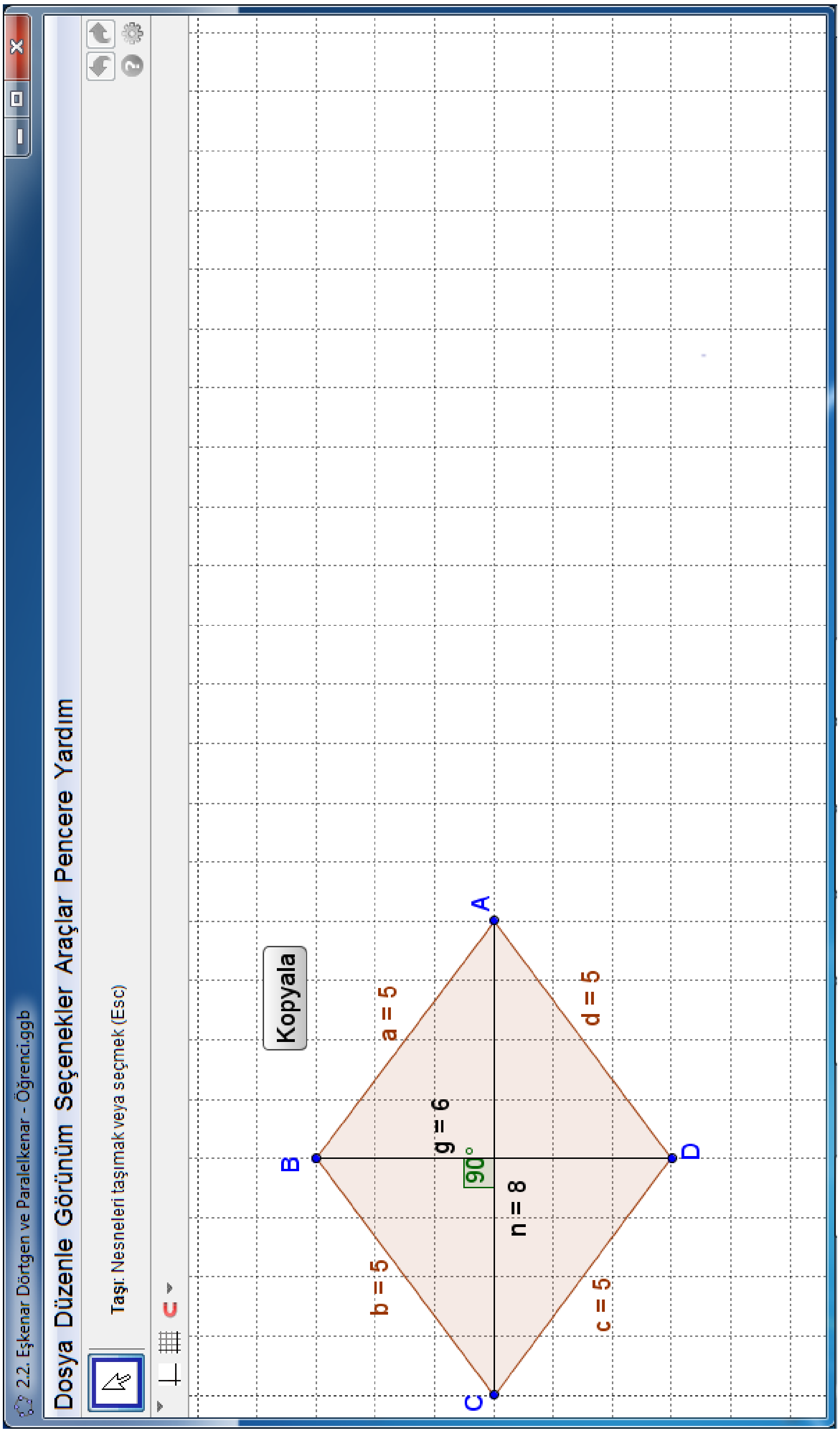
Activity 2: The Relationship between Parallelogram and Rectangle



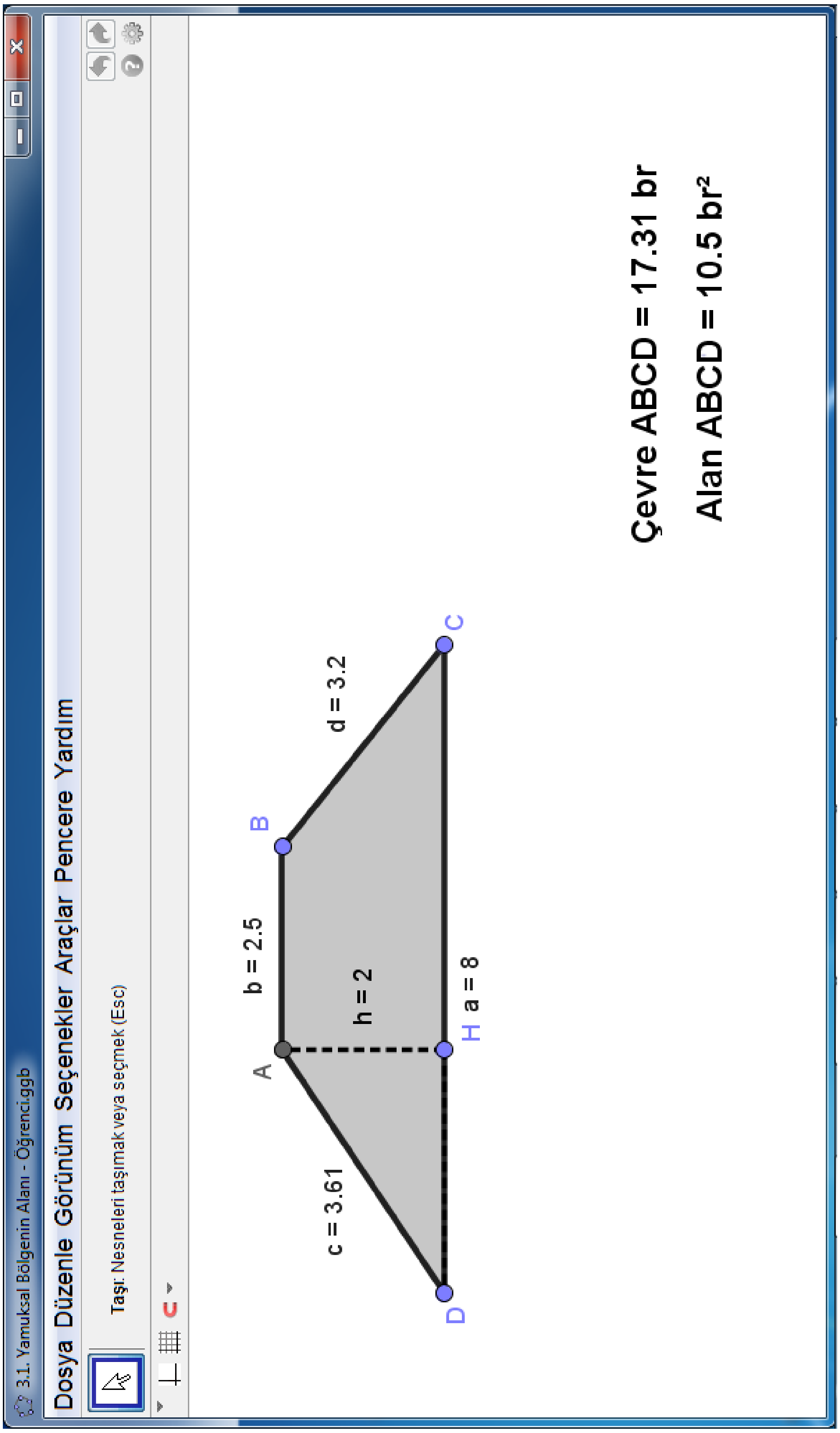
Activity 3: Area of Rhombus



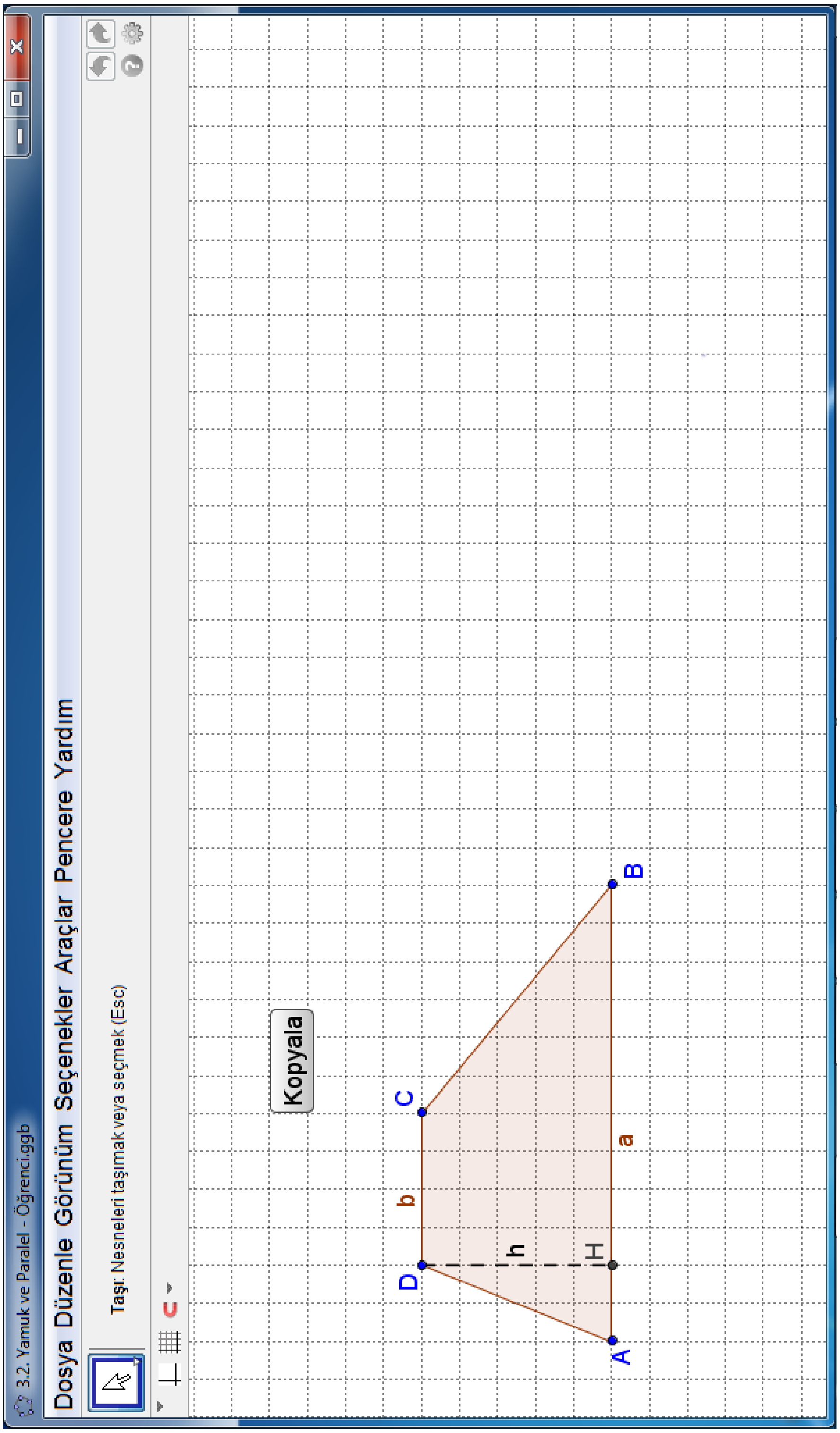
Activity 4: Area Relationship between Rhombus and Parallelogram



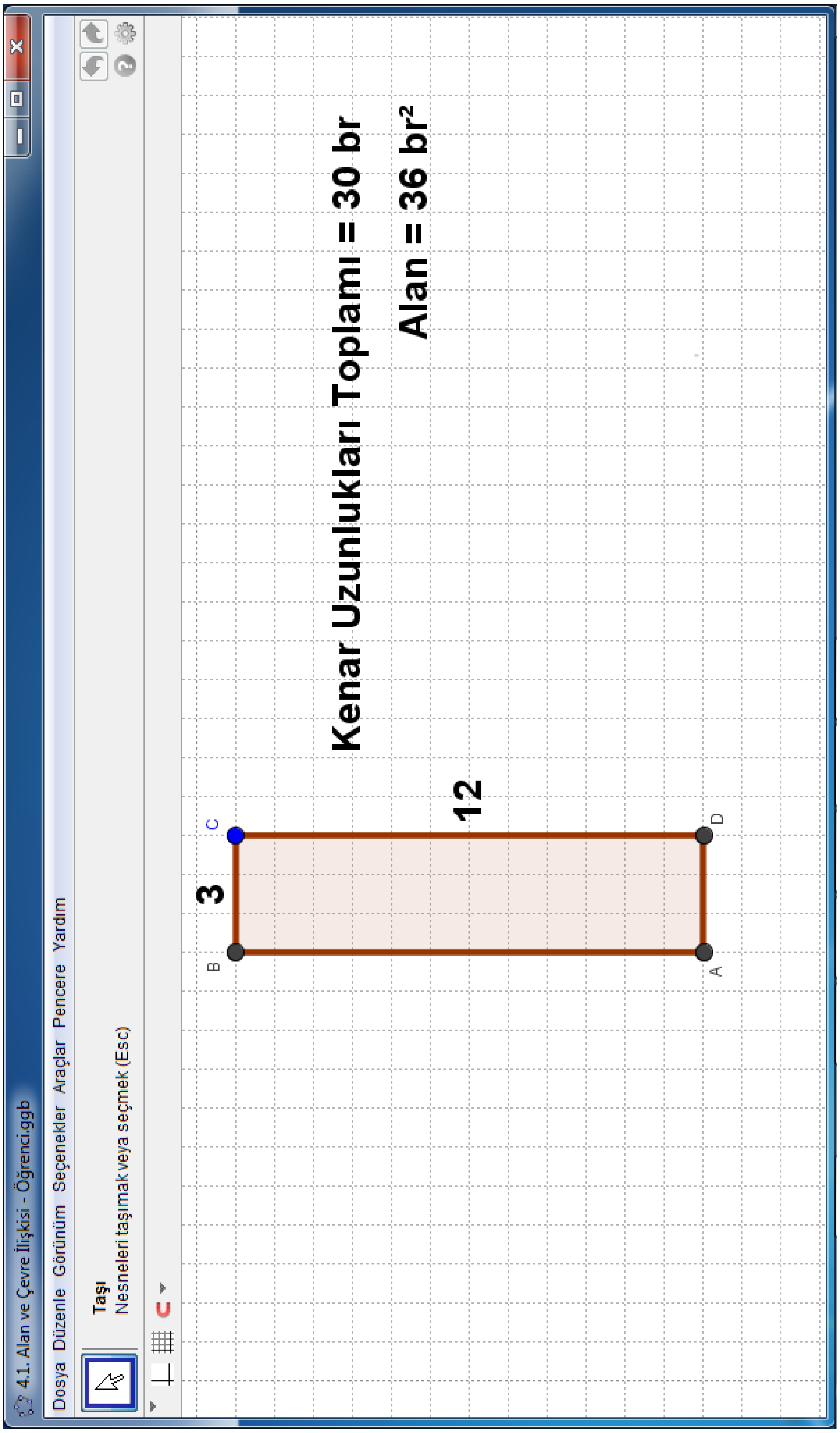
Activity 5: Area of Trapezoid



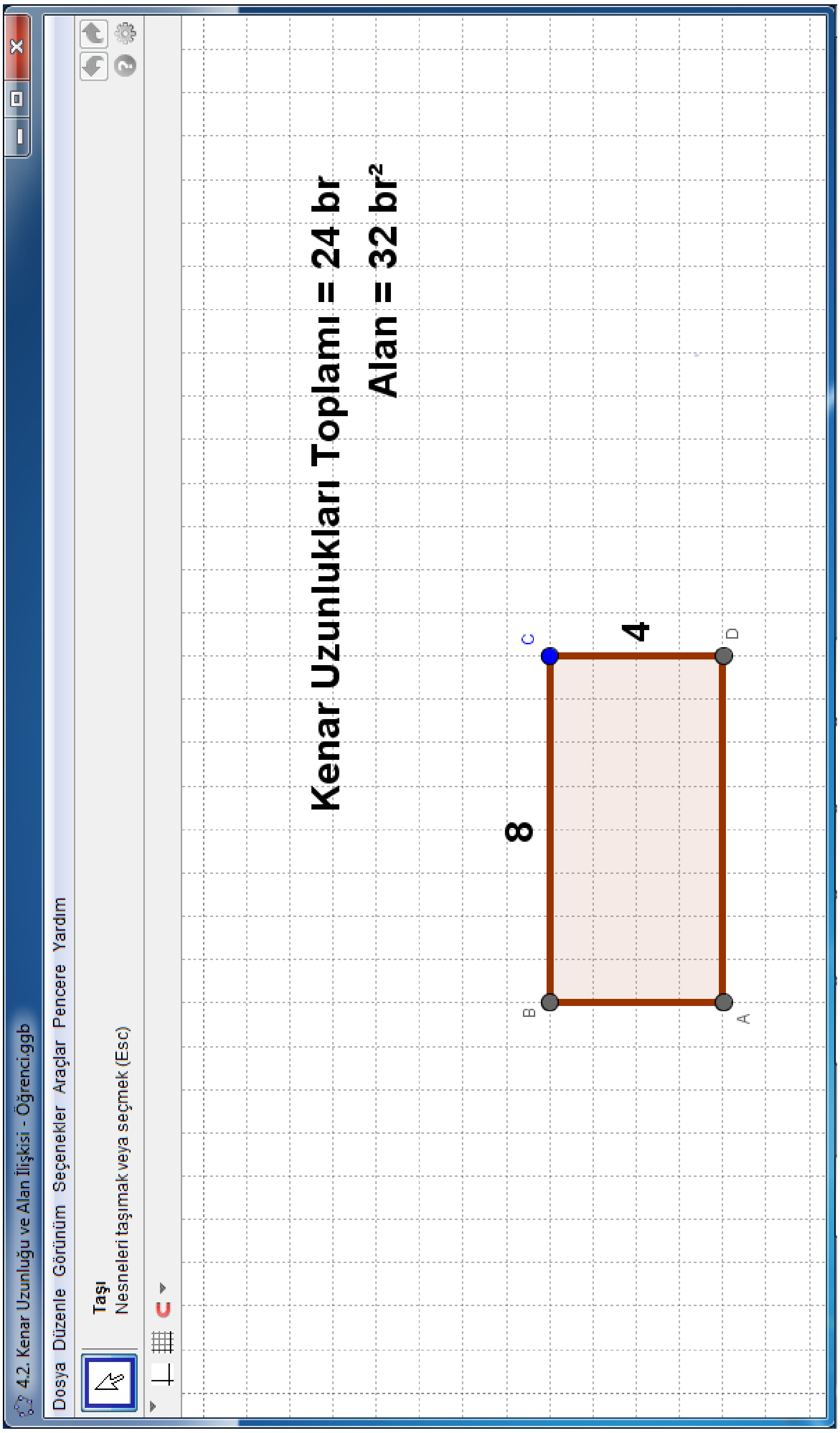
Activity 6: Area Relationship between Trapezoid and Parallelogram



Activity 7: The Relationship between Area and Perimeter



Activity 8: The Relationship between Side Length and Area

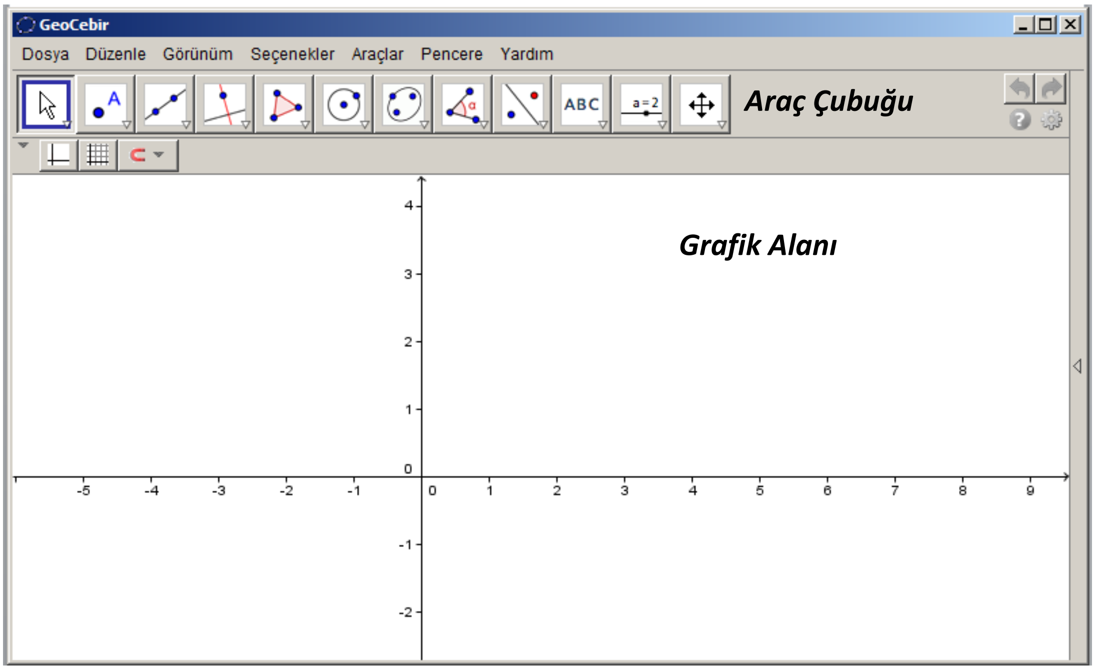


APPENDIX J

GEOGEBRA MANUAL

Bu ders sürecinde Matematik derslerini GeoCebir Programı ile işleyeceğiz. Bu kılavuz ders sürecinde sizlere kolaylık sağlamak için hazırlanmıştır.

GeoCebir Programı



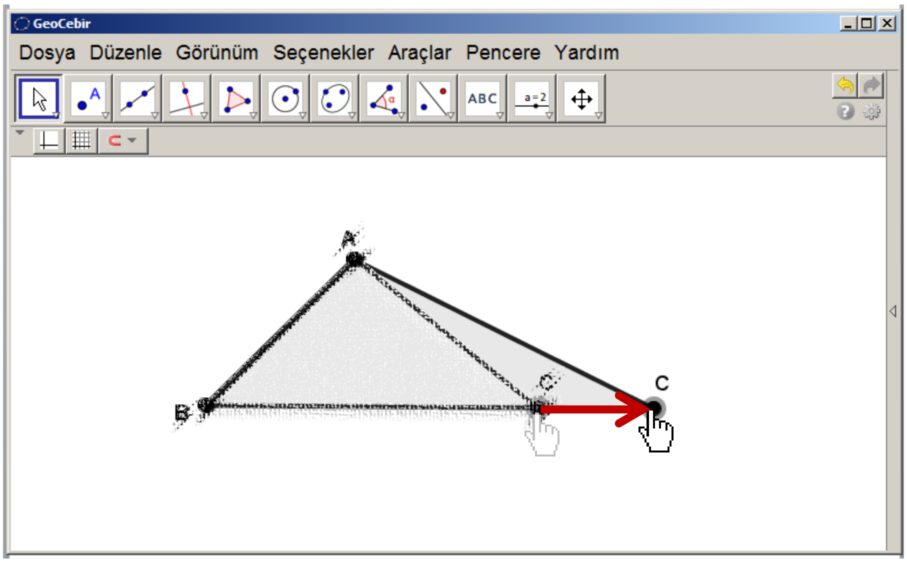
Grafik Alanı: *Etkinlikler süresince dörtgensel bölgelerin çizimleri ve gösterimlerinin yer alacağı bölüm.*

Araç Çubuğu: *Etkinliklerde "Çevre Uzunluğu", "Alan Ölçüsü", "Kenar Uzunluğu", vb. ölçüleri bulmamız istendiğinde kullanacağımız araçların yer aldığı bölüm.*

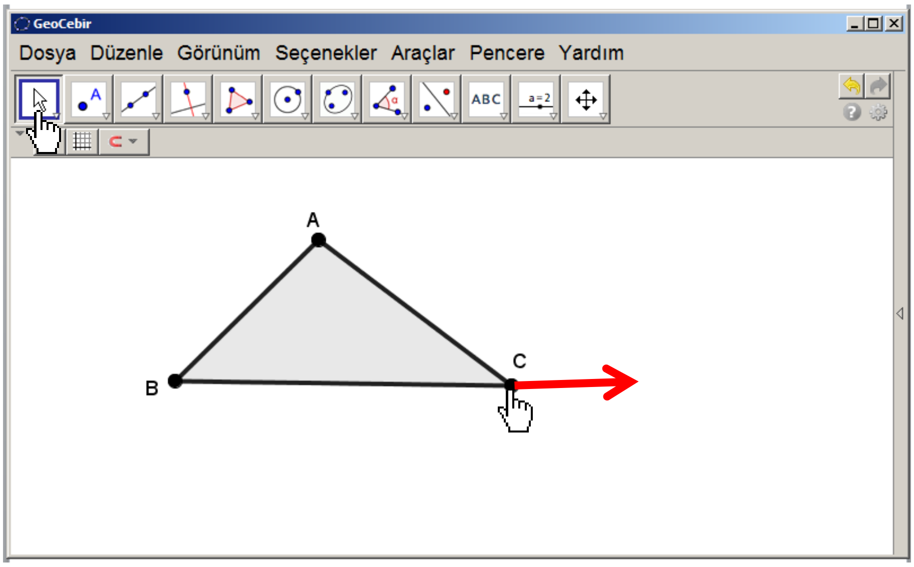
1. Verilen Şeklin Kenar ya da Köşe Noktaları Hareket Ettireceğimiz Durumlar:

GeoCebir Programında verilen bir çokgenin köşe noktalarının hareket edebildiği ve hangi yönlere hareket edebildiği belirtildiyse,

- ✓ Bahsedilen noktayı fare yardımıyla seçerek (fareyi nokta üzerine getirip sol tuşa basılı tutarak) belirtilen yöne doğru sürükleyerek, gerçekleşen değişimleri gözlemleyebiliriz.

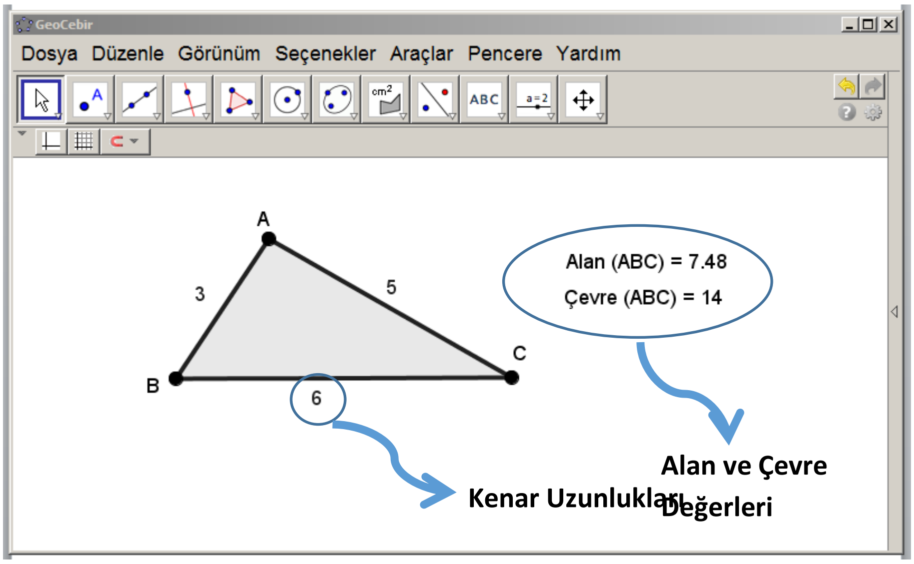


- ✓ Hareket ettirme işlemini tamamladıktan sonra farenin sol tuşunu bırakabilirsiniz.
- ✓ Hareket ettirme işlemine başlamadan önce araç çubuğundan “Taşı” aracının seçili olması gerekmektedir. Bu yüzden hareket ettirme işleminden önce araç çubuğundan “Taşı” aracını seçiniz.



2. Noktaları Hareket Ettirilebilen Şekillerin Çevre, Kenar ve Alan Ölçüleri:

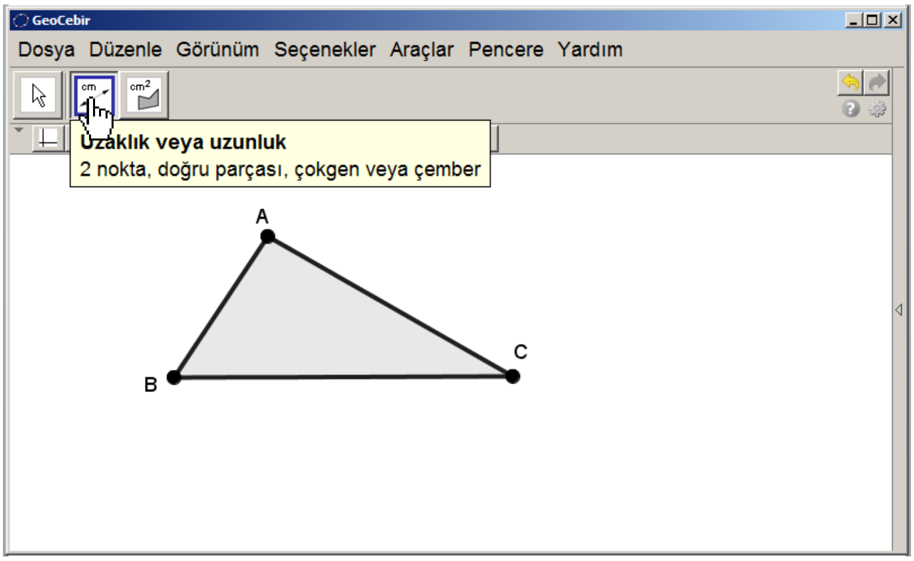
- ✓ GeoCebir ile işlenen Matematik dersleri boyunca verilen şeklin noktalarını sürükleyerek, konumlarını değiştirdikten sonra Çevre, Kenar ve Alan ölçülerindeki değişimleri gözlemleyerek sizlere dağıtılan çalışma kağıtlarında ilgili tablolara yazmanız istenecektir.



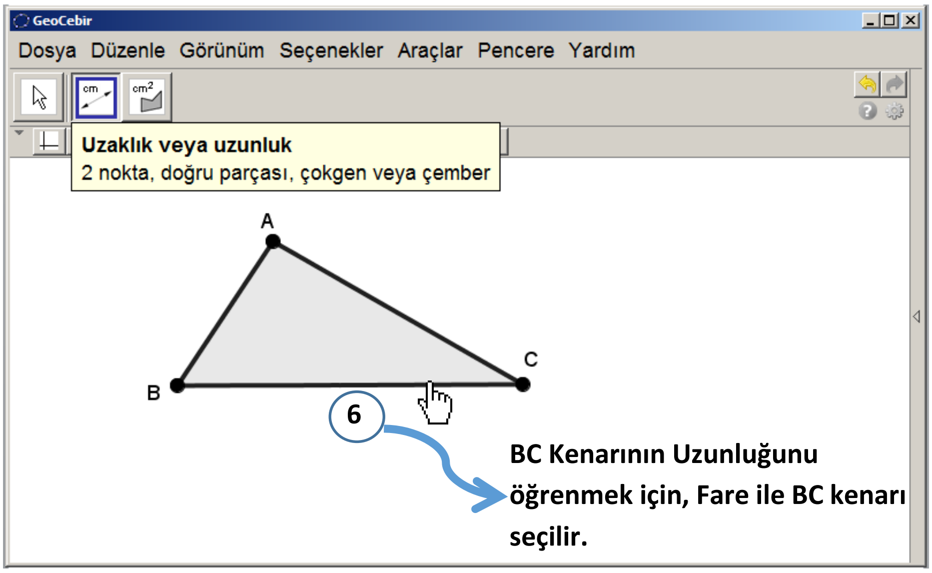
Yukarıdaki şekilde Kenar, Çevre ve Alan ölçülerindeki değişimleri gözlemeyebileceğiz alanlar gösterilmiştir.

3. Kenar Uzunluğu ve Çevre Uzunluğu Ölçme:

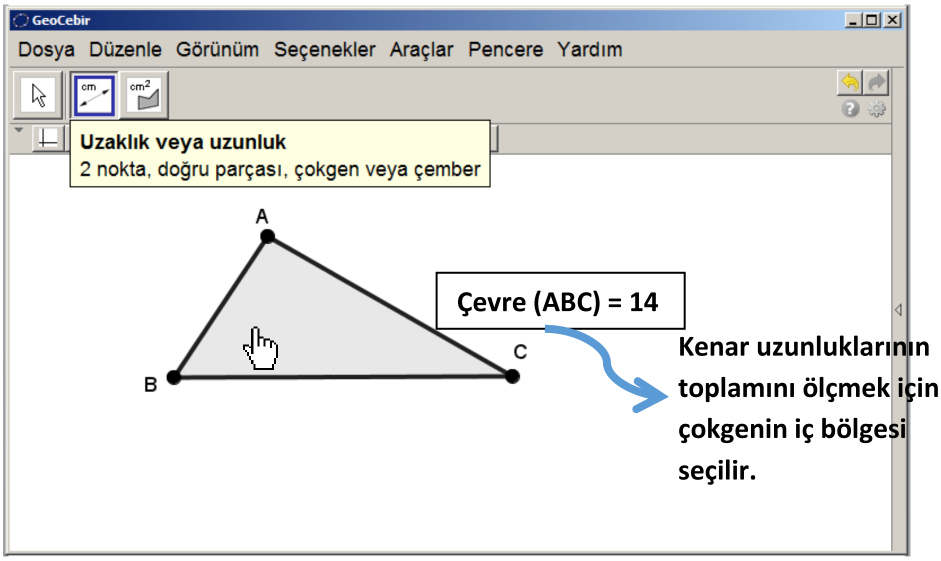
✓ Araç Çubuğunda yer alan "Uzaklık veya Uzunluk" aracını kullanarak verilen çokgenin kenar ve çevre uzunluğunu ölçebiliriz.



- ✓ Çokgenin bir kenarının uzunluğunu ölçmek için "Uzaklık veya Uzunluk" aracı seçildikten sonra ölçülmek istenen kenar fare ile seçilir.

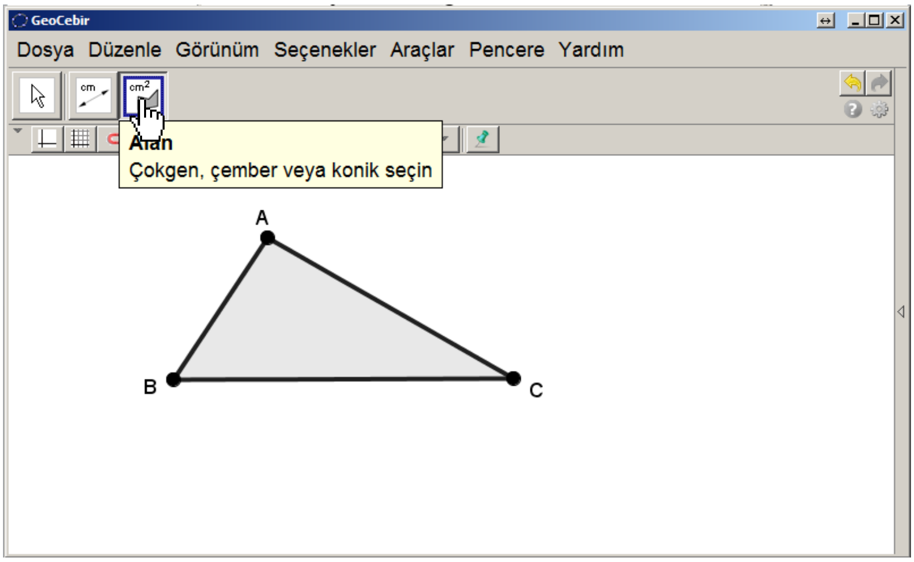


- ✓ Çokgenin kenar uzunluklarının toplamını ölçmek için ise "Uzaklık veya Uzunluk" aracı seçildikten sonra çokgenin iç bölgesi fare ile seçilir.

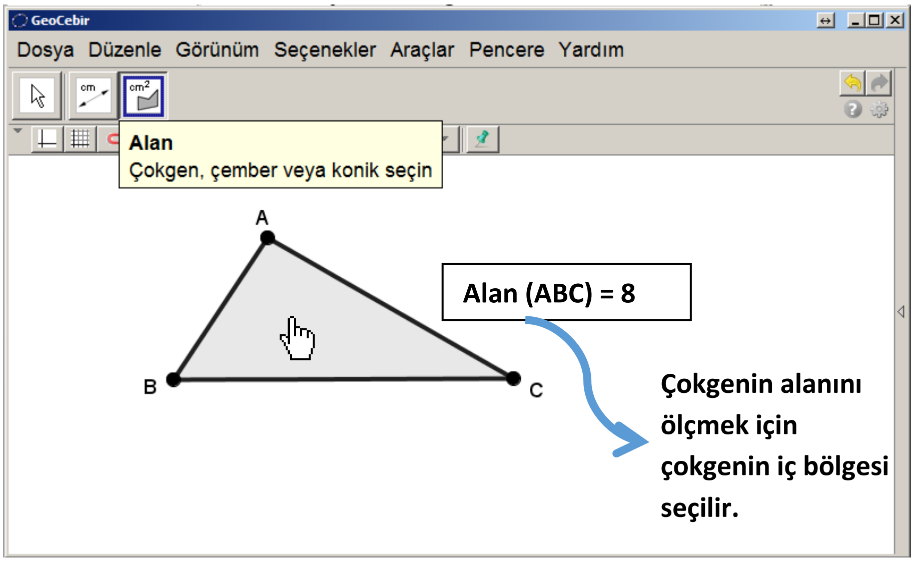


4. Alanı Ölçme:

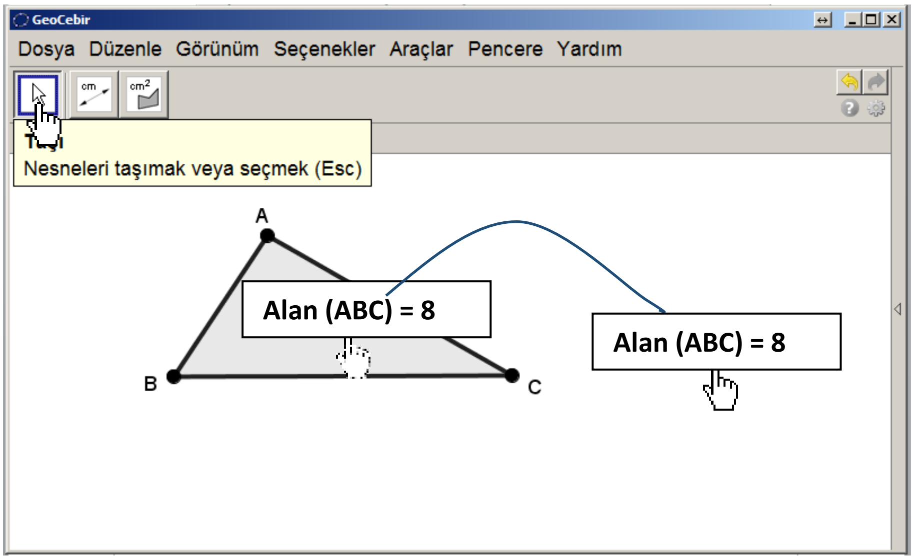
- ✓ Araç çubuğunda yer alan “Alan” aracını kullanarak verilen çokgenin alanını ölçebiliriz.



- ✓ Çokgenin alanını ölçmek için “Alan” aracı seçildikten sonra çokgenin iç bölgesi fare ile seçilir.



5. Ölçülen Değerleri Boş Alanlara Taşıma:



- ✓ Araç çubuğunda yer alan "Taşı" aracını kullanarak ölçülen değerlerin yer aldığı yazıları boş alanlara taşıyabiliriz.

APPENDIX K

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☑

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : ÖZÇAKIR
Adı : Bilal
Bölümü : İlköğretim Fen ve Matematik Eğitimi

TEZİN ADI : The Effects of Mathematics Instruction Supported by Dynamic Geometry Activities on Seventh Grade Students' Achievement in Area of Quadrilaterals

TEZİN TÜRÜ : Yüksek Lisans ☑ Doktora ☐

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

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: