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THE EFFECTS OF USING CONCRETE MANIPULATIVE AND GEOGEBRA ON FIFTH GRADE STUDENTS' ACHIEVEMENT IN QUADRILATERALS

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THE EFFECTS OF USING CONCRETE MANIPULATIVE AND GEOGEBRA ON FIFTH GRADE STUDENTS' ACHIEVEMENT IN QUADRILATERALS

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ABSTRACT

THE EFFECTS OF USING CONCRETE MANIPULATIVE AND GEOGEBRA ON FIFTH GRADE STUDENTS' ACHIEVEMENT IN QUADRILATERALS

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This study aims to examine the effects of activity-based learning using concrete manipulatives and using GeoGebra on 5th-grade students' achievements in quadrilaterals as compared to activity-based learning only. The other purpose is to gain in depth understanding about the effects of used materials (GeoGebra and concrete manipulatives) on students' explanations on quadrilaterals through conducting interviews. A quasi-experimental mixed method research method was used to examine the related research questions with two experimental groups and one control group. Semi-structured interviews were conducted to gain an in-depth understanding of the effects of used materials (GeoGebra and concrete manipulatives) on students' explanations. This study was implemented in the spring semester of the 2015-2016 academic years in a middle school in Düzce which is located in the West Black Sea Region in Turkey with 60 students whose were 35 girls and 25 boys. The study was carried 14 class hours (3 weeks). The quantitative data was collected from Quadrilateral Achievement Test and to be analyzed by the help of analysis of covariate (ANCOVA). Furthermore, one student was selected from each group according to their being talkative, enthusiastic and successful for interviews to obtain rich data in qualitative part. Both quantitative and qualitative data analysis indicated that using GeoGebra in activity-based learning while learning quadrilaterals had a positive effect on the students' achievement and enhanced students' perception.

Keywords: Dynamic Geometry Software, Concrete Manipulative, Quadrilateral, Geometry, 5th-grade students

ÖZ

GEOGEBRA VE SOMUT MATERYAL KULLANIMININ BEŞİNCİ SINIF ÖĞRENCİLERİNİN DÖRTGENLER KONUSUNDAKİ BAŞARISI ÜZERİNDE ETKİSİ

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Bu çalışmanın amacı GeoGebra kullanarak aktivite temelli öğrenme ortamının ve somut materyal kullanarak aktivite temelli öğrenme ortamının sadece aktivite temelli öğrenme ortamı ile karşılaştırıldığında beşinci sınıf öğrencilerinin dörtgenler konusundaki başarısını araştırmaktır. Buna ek olarak, kullanılan materyallerin öğrencilerin açıklamaları üzerinde etkisini derinlenmesine incelemek için görüşmeler gerçekleştirilmiştir. Bu çalışmada iki deneysel ve bir kontrol grubunu içeren yarı deneysel karma araştırma deseni kullanılmıştır. Nitel tasarım için, yarı yapılandırılmış görüşme formları tercih edilmiştir. Çalışma, 2015-2016 eğitim öğretim yılının ikinci döneminde Düzce'de bir ortaokulda gerçekleştirilmiş ve 14 ders saati (3 hafta) sürmüştür. Verilerin toplanabilmesi için, araştırmacı tarafından önceki çalışmalardan elde edilen soruların kullanılmasına dayalı "Dörtgenler Başarı Testi" kullanılmıştır ve kovaryans analizi (ANCOVA) ile veriler incelenmiştir. Nicel verilere ek olarak, görüşmeler uygulamanın hemen ardından yapılmıştır Bu aşamada, üç öğrencinin açıklamalarına ve cevaplarına yer verilmiştir. Bu üç öğrencinin her biri ayrı sınıftan seçilmiş olup, seçilme işlemi sürecinde daha zengin veri elde edebilmek için öğrecilerin konuşkan, görüşmeye katılmayı hevesli ve başarılı olması gibi etkenler göz önünde bulundurulmuştur. Nicel ve nitel verilerin analizleri GeoGebra kullanarak aktivite temelli öğrenme ortamının dörtgenler konusunu öğrenirken öğrenciler üzerinde pozitif bir etkiye sahip olduğunu ve öğrencilerin bakış açılarını genişlettiğini göstermektedir.

Anahtar Kelimeler: Dinamik Geometri Yazılımı, Somut Manipulatif, Dörtgenler, Geometri, 5. Sınıf öğrencileri

To My Lovely Mum

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DGS	Dynamic Geometry Software
CAS	Computer Algebra System
MoNE	Ministry of National Education
NCTM	National Council of Teachers of Mathematics
NETS	National Educational Technology Standards for Students
QAT	Quadrilateral Achievement Test
VHLT	van Hiele Geometric Thinking Level Test
N	Sample size
ANCOVA	Analysis of Covariance Analysis
df	Degree of freedom
Sig.	Significance
α	Significance Level

CHAPTER 1

INTRODUCTION

Geometry can be defined as one of the crucial components of mathematics learning according to National Council of Teachers of Mathematics in the United States (NCTM, 1991). Principles and Standards for School Mathematics states that "geometry is a natural area of mathematics for the development of students' reasoning and justification skills", and therefore, it provides the opportunity learners to analyze, describe, and understand their physical environment (NCTM, 2000, p. 3). Students may gain some insights about two and three-dimensional objects through interpreting their environment. Similarly, geometry helps students conceptualize and look at spatial objects which they observe in their environments (Battista, 2007). Geometry teaching is necessary for many areas for several purposes such as engineering, architecture, science, designing and education (Laborde, Kynigos & Strasser, 2006). In addition, many ideas in mathematics are based on geometric thinking (Clements & Sarama, 2011). It has contributed to the other areas of mathematics such as algebra, measurement and rational numbers (NCTM, 2000). It helps students gain some cognitive skills such as individual reasoning, problem-solving, and critical thinking and enables them to set up the cause and effect relationship with higher order thinking skills (Clements & Sarama, 2011). Developing geometric thinking of students, geometry has a crucial place in education (Arcavi, 2003; Ubuz, Üstün & Erbaş, 2009). Parallel to these, geometry is defined as one of the content areas in mathematics curriculum under the name of "Geometry and Measurement" and it is found in all class levels of elementary education (MoNE, 2013). Moreover, geometry plays an important role in international studies and national standardized achievement tests (Mullis et al., 2004). On the other hand, Mullis et al. (2004) stated that according to the result of the international studies, students do not show adequate performance in geometry in many countries. Considerable research has shown that Turkey can be considered one of these (Olkun & Aydoğdu 2003). To illustrate, according to the international studies, such as the repeat of Programme for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS-R), the achievement level of Turkish students on the content area ‘geometry’ is low (Ubuz, Üstün & Erbaş, 2009). Similarly, TIMSS 2015 results showed that the scores of 4th-grade and 8th-grade students in Turkey have been below average in terms of geometry and measurement content area (Erbilgin, 2017; MoNE, 2016; Topçu, Erbilgin & Arıkan, 2016). Similar to international exams, national exams in Turkey also reveal low performances of Turkish students. For example, there are 30 geometry questions in LYS (Undergraduate Placement Exam), the second stage of the university examination system in Turkey and the results of LYS 2016 showed that the mean of the geometry scores is 4.22. According to these results, it can be concluded that Turkish students have difficulty in geometry.

The main aim of geometry education for grades 3-5 is to offer students some skills such as identifying, analyzing, classifying, and drawing both two and three-dimensional shapes based on their properties, verbally describing and defining them based on their attributes, making connections to both other sciences and everyday life situations through recognizing geometric relationship and ideas (NCTM, 2000). Likewise, the Ministry of National Education stated that the main aims of primary level mathematics curriculum are to deal with the visual properties of geometric shapes, objects, and structures included in their daily life, and to analyze the properties of shapes, objects, and structures (MoNE, 2013). Students should be able to separate and classify geometric objects according to their common characteristics. Hence, it is expected from students to gain some cognitive skills such as spatial abilities, individual reasoning, problem-solving, and critical thinking. Kaufmann, Steinbügl, Dünser, and Glück (2005) emphasize that geometry education is a special means of developing such skills as spatial thinking. Sinclair et al. (2015) mentioned that “One’s understanding of the nature of geometry determines one's sense of the aims of geometry in school mathematics" (p.4). For this reason, geometry should have an important place in mathematics education. It is recommended in current mathematics curriculum of Turkey that teachers use drawings, concrete manipulatives, and dynamic software while teaching geometry and design student-centered lessons. In this way, it is assumed that students construct meaningful knowledge since learning environments play a crucial role in reaching such goals in geometry education (NCTM, 2000). Similarly, Hunt, Nipper, and Nash (2011) argue that students construct a conceptual understanding of topics in mathematics education through using manipulatives. Manipulatives are concrete objects that are designed to enable learners to acquire mathematical concepts through concrete experiences (Bouck & Flanagan, 2010; Suh & Moyer, 2008). In other words, concrete manipulatives enable students to physically interact with objects through feeling, seeing, and touching (Carbonneau & Marley, 2012).

Teachers are suggested to use concrete manipulatives and technological instruments as well as textbooks in mathematics lessons and to prepare activities based on the usage of these manipulatives (MoNE, 2013). Many researchers have supported the use of concrete manipulatives and technological tools in mathematics education while transforming experiences from concrete into abstract ideas (Sherman & Bisanz, 2009; Boggan, Harper & Whitmire, 2010). It is emphasized that using manipulatives has enhanced motivation and attraction of students (Fennema, 1973). The National Council of Teachers of Mathematics has suggested that students use manipulatives to make a transition and to improve their mathematical understanding (NCTM, 2000). In addition, teacher education textbooks recommend that teachers use concrete manipulatives during their mathematics instruction and use materials that are consistent with both the content and the teaching methods (Billstein, Libeskind & Lott, 2009; Copley, 2000). Concrete manipulatives are used for building skills, knowledge, and confidence in many context areas of mathematics such as algebra, probability, and geometry to enable students to practice with numbers, to explore ideas from statistics and probability, and to explore characteristics of polygons (NCTM, 2000). There are many types of concrete manipulatives that can be used from daily life. Using the money to teach basic arithmetic functions is an example of using concrete manipulatives from daily life in mathematics (Carbonneau, Marley & Selig, 2013). Geoboard and geometry tiles are two kinds of these concrete manipulatives as purchasing objects. Geoboard is a concrete manipulative used for the present study and it consists of nails placed at equal intervals on the geometry board. There are two types of geoboards: circular and square. Various geometric shapes can be formed on the geometry board with string or rubber band and students get a chance to interpret constructed shapes, compare them, and easily explore environmental or field relations of shapes. Geoboard is used to teach various geometry topics such as straight lines, angles, and polygons as well as fractions and measurement (NCTM, 2000). It enables students to construct and observe spatial visualization of shapes and properties (Kennedy & McDowell, 1998). Geometry strip is the other concrete manipulative selected for the current study. Geometry strip is a material which helps students construct geometric shapes and grasp the meaning of those shapes, and apertures of geometry strips are provided with equal lengths of the plastic strips of various lengths and in various colors if they are equally spaced. Students create the desired length of this material by passing pins through the holes on the strips. Generally, it is used in geometry topics such as quadrilaterals and angles. It is used by all levels of students in different areas of mathematics and geometry (NCTM, 2000).

To sum up, the use of concrete materials in instruction may help students have an idea about the concepts of mathematics, gain conceptual understanding and construct a relationship between mathematical symbols and real-world cases (Heddens, 2005). Moreover, some research on concrete manipulatives indicates that using manipulatives in lessons has positive effects on learning mathematics (e.g. Beougher, 1967; Burns, 2006; Heddens, 2007). Similarly, it is mentioned that using concrete materials creates a rich learning environment with the aid of visualizations and feeling and motivates students towards the course (Castro, 2006;

Driscoll, 1981; Sowell, 1989; Suydam, 1986). In addition to using concrete materials in mathematics education; mathematics teaching, especially geometry teaching has been reshaped in recent years through the developments in technology. New teaching and learning opportunities have been created via technological tools which support students to gain different mathematical skills (Hollebrands, 2007). When Turkish mathematics curriculum is analyzed, it can be seen that teachers are recommended to use technology in geometry education especially while teaching dynamic geometry (MoNE, 2013). Using technology effectively in geometry education can be assumed to enhance students' involvement and motivation. Kaufmann, Steinbülg, Dünser, and Glück (2005) propose that a learning environment supported with technological tools enables learners to do more experimentation when compared to traditional instructions. Furthermore, many studies show that teachers have positive manners towards using technology in education (Çağıltay, Çakıroğlu, Çağıltay & Çakıroğlu, 2001; Myers, 2009; Sauter, 2001; Smith, 2010; Tayan, 2011; Ubuz, Üstün & Erbaş, 2009). As a result of these, today's technology has presented several educational tools that can be grouped under two main headings in mathematics: Computer Algebra Systems (CAS) and Dynamic Geometry Software (DGS) (Ruthven, 2009). Computer Algebra System (CAS) combines algebra and technological system, enabling users to generate graphical, numerical, and symbolic representations. On the other hand, Dynamic Geometry System (DGS) provides learners with the chance to create geometric constructions, manipulate them, explore, practice and visualize concepts of mathematics. This system enables learners to construct shapes whose properties are conserved if they are constructed correctly. In other words, when the shape is constructed, even if some properties such as size are changed, the basic properties are conserved (Dye, 2001). This implies that learners get a chance to resize and move constructed shapes or objects easily on the computer screen (Kaufmann, & Schmalstieg, 2006). Moreover, it enables teachers to develop the communication between teachers and students and to prepare teaching materials (Majewski, 1999). Thanks to DGS, students have the opportunity to construct their own problems by getting connections among operations and concepts, and to manipulate the problems, and they can analyze and check ideas with trial and error (Forsythe, 2007). DGS is one of the most widely preferred software in schools all over the world (Sträßer, 2002). Some well-known Dynamic Geometry Software (DGS) programs are GeoGebra, Geometer's Sketchpad, and Cabri. GeoGebra is selected for the current study as the technological tool since it is a free and open source supported by multi-language usage. In addition, users just need basic computer skills to benefit from it, which makes it more preferable (Hohenwarter, Hohenwarter & Lavicza, 2010). This means that its users do not have to have special computer skills. Moreover, GeoGebra combines some basic properties of computer algebra system and dynamic geometry systems (Doktoroğlu, 2013; Hohenwarter & Jones, 2007; Hohenwarter, & Preiner, 2007). Thanks to this software, all properties of original constructions and their relationships are kept (Lehrer, & Chazan, 2012). In other words, when a shape is constructed or drawn, object or lines, points, vectors, segments, angle, conic are modified, but the relationship among them is maintained (Dye, 2001). The usage of dynamic geometry software is valuable since it enables students to make a conjecture among topics. In this way, an interconnection among mathematical topics is provided. For example, while students are exploring the properties of the right triangle, they may notice the Pythagoras Theorem (provided students know root numbers). In this way, even if they notice the theorem individually, they can check the theorem through many examples with the help of GeoGebra. Moreover, it provides users with the support to pose a problem, hypothesizes ideas and justifies arguments as a proof (Laborde, 2000). It also enables students to visualize geometric objects since visualization process plays a crucial role in geometric thinking (Presmeg, 2006). Dynamic geometry software helps students to gain experience and conjecture about geometrical objects and relationships (Healy & Hoyles, 2002).

Quadrilaterals and defining their common properties are two of the core topics in geometry education since it is crucial for almost all grades from pre-kindergarten to higher education (MoNE, 2013). Similarly, the Geometry Standard from the National Council of Teachers of Mathematics Principles and Standards for School Mathematics mentioned that “students should be able to analyze the characteristics and properties of two- and three-dimensional geometric objects, classify them based on such properties” (NCTM, 2000, p. 41). This indicates that there is an agreement on the aims of geometry in education systems. In addition, quadrilaterals provide a rich perspective for learners to examine in their environment (Furinghetti, & Paola, 2003). Definitions play an important role in mathematics education since thanks to definitions, students gain cognitive skills such as proof making; problem-solving and identifying mathematical objects (Silfverberg, 2003). For this reason, definition, understanding definition and identification of an object have a big place in quadrilateral education (Fujita & Jones, 2007). Classification and definition of quadrilaterals are interrelated with each other. On the other hand, numerous studies have implied that learners generally have difficulty in the definition and hierarchical classification of quadrilaterals (Currie & Pegg, 1998; Erez, & Yerushalmy, 2006; Fujita & Jones, 2007; Monaghan, 2000; Pickreign, 2007). One of the reasons is that classification and definition require a high level of cognitive skills (De Villiers & Govender, 2002). Most of the students do not gain such cognitive skills as deductive reasoning, and logical thinking. In addition to this, the existence of inclusive and exclusive definitions can be considered as another reason (Hansen & Pratt, 2005). This originates from a disagreement about the definitions of the trapezoid (Usiskin & Griffin, 2008). In addition, a collision between their personal definition and formal definition may cause difficulty in quadrilateral education (Kuzniak & Rauscher, 2007). For these reasons, it is decided to check the effects of using concrete manipulatives, and using GeoGebra on 5th-grade students’ in a quadrilateral topic.

1.1 Purpose of the Study

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to using activity-based learning only. The other purpose is to gain in depth understanding of the effects of the used materials (GeoGebra and concrete manipulatives) on students' explanations of quadrilaterals through conducting interviews.

1.2 Research Questions and Hypotheses for the Study

The study aimed at answering following main research question:

Main Research Problem: After controlling students' pre-test results, what is the effect of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals when compared to a control group that in which only activity-based learning was implemented?

Null Hypothesis (H_0) = There is no statistically significant effect of activity-based learning using GeoGebra and activity-based learning using concrete manipulative on 5th-grade students' achievement with respect to Quadrilateral Achievement post-test results after controlling Quadrilateral Achievement Test pre-test results.

In addition, this study aimed to investigate the following quantitative and qualitative sub-research questions.

SB) Is there a significant mean difference between the activity-based learning using concrete manipulative and activity-based learning only with respect to Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pretest result?

Null Hypothesis (H_0) = There is no statistically significant mean difference between activity-based learning using concrete manipulative and activity-based learning only with respect to Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pretest result.

SB3) Is there a significant mean difference between the activity-based learning using GeoGebra and activity-based learning only in quadrilaterals with respect to

Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pre-test result?

Null Hypothesis (H_0) = There is no statistically significant mean difference between the activity-based learning using GeoGebra and activity-based learning only in quadrilaterals with respect to Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pretest result.

SB4) How do the students' solutions and explanations change when they learn quadrilaterals by using different materials?

1.3 Significance of the Study

The aim of teaching geometry is to enable learners to interpret geometric relationships, to gain spatial reasoning, geometric modeling, and geometric intuition (NCTM, 2000). Geometry teaching enables learners to improve their spatial thinking, deductive reasoning and visualization skills (Battista, 2007). In addition, geometry requires having such cognitive processes as construction, visualization, and reasoning (Laborde, Kynigos, Hollebrands & Strasser, 2006, p.276). For this reason, learning geometry is a difficult subject for learners since it requires more than one process or skill in the process of meaningful learning (Öztoprakçı, 2013). As a result, teachers face big challenges while teaching it. For mathematics teachers, it is difficult to decide how to teach geometric concepts (Žilinskiene, & Demirbilek, 2015). Moreover, teaching mathematics in Turkey, especially teaching geometry has been reformed in recent years as concrete manipulatives and certain innovative developments in technology has been integrated into education more.

Technology has become an essential part of teaching and learning of mathematics. (NCTM, 2000). Thanks to the support of technological tools in education, students find the opportunity to construct conceptual understanding through observation and exploration since technological tools enable learners to construct their own knowledge, make a connection among mathematical concepts, create a problem and get feedback about their actions during the solution of some problems. On the other hand, Kulik (1994) and Sivin-Kachala (1998) stated that the effectiveness of educational technology depends on the student population, the design of software, the role of the educator, and the availability of technology for the students as well as its accordance with the area of topic. In addition to this, some studies on teachers' opinion on technology usage show that teachers have fears while using technology in their lessons as an instructional tool (e.g. Guerrero, Walker & Dugdale, 2004; Schmidt & Callahan, 1992). Besides using technology, teachers should be encouraged to use concrete manipulatives in mathematics lessons and to design their lessons by using them (NCTM, 2000).

Using manipulatives in lessons enables students to gain basic achievement and skills as well as arousing students' interest to geometry. Moreover, students have a chance to make a connection among mathematics and geometry. Research indicates that using manipulatives in lessons provides students with the chance to transform abstract ideas into concrete structures (Burns, 2006; Heddens, 2007). The cited research studies mainly focus on using GeoGebra during regular geometry instruction or just using concrete materials during geometry education and less has been done about the comparison among the usages of GeoGebra in activity-based learning, concrete material in activity-based learning, and just activity-based learning. Moreover, quadrilaterals and defining their common properties are two of the core topics in geometry education since they are crucial for almost all grades from preschool to higher education. Additionally, Furner and Marinas (2013) state that the surrounding area of children and the objects around them have a background in geometry and the first geometrical objects children are introduced are generally quadrilateral objects. Because of its big place in elementary and middle school curricula and children's daily lives, it is crucial for middle school students to learn basic knowledge about quadrilaterals to continue their education life successfully in the following years.

The current study aims to investigate how GeoGebra and concrete manipulatives enhance students' learning in quadrilaterals. Appropriate lesson plans on quadrilaterals are developed to be used with both GeoGebra and concrete manipulatives to conduct the current study, which might be considered as examples for the teachers about technology and concrete manipulative usage in their classroom. The progress and development of such lesson plans can contribute to instructions and provide an opinion for teachers, curriculum developers, and educational policy makers.

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to activity-based learning only.

1.4 Definition of Important Terms

Quadrilateral: A quadrilateral is generally defined as a polygon with the closed four-sided plane figure (Usiskin et al, 2008).

Dynamic Geometry Software: Dynamic Geometry Software is defined as a combination of computer algebra and dynamic geometry systems. Dynamic geometry software allows users to create and manipulate constructions. Meanwhile, all the relationships in construction are preserved (Hohenwarter & Jones, 2007).

GeoGebra Software: GeoGebra, which was created by Markus Hohenwarter, is interactive geometry software used for constructing geometric objects such as points, vectors, segments, lines, polygons, conic sections, and functions that can be changed dynamically, (Hohenwarter, Hohenwarter & Lavicza, 2010).

Concrete Manipulative: Concrete manipulative can be considered as valuable mathematical tools that used for teaching mathematical concepts.

5th-Grade Students: Fifth grade students are registered in the first year of middle school. The age of these students ranges from 10 to 12.

CHAPTER 2

LITERATURE REVIEW

This chapter includes basic information about the place of concrete manipulative in education as well as related research on the usage of manipulative in mathematics lessons, the place of technology in education and giving information on related research on using the dynamic software in mathematics lessons and definition of quadrilaterals and studies related to the definition of quadrilaterals.

2.1 Place of Concrete Manipulatives in Geometry Education

Concrete manipulatives are physical objects that are used for the introducing, teaching, reinforcing and practicing of mathematical concepts (Uribe-Florez & Wilkins, 2010; Burns & Hamm, 2011). Using manipulatives in mathematics lesson provides students experiential learning by physical interaction with objects (Carbonneau & Marley, 2012) since concrete manipulatives address learners' several such senses as feeling, touching and seeing (Carbonneau & Marley, 2012; Heddens, 2005; Kober, 1991; Reys, 1971). To put it differently, they enable students to examine, think, deduce and develop well-grounded mathematical ideas in more significant ways (Stein & Bovalino, 2007). They have positive effects on students' understanding of mathematical concepts as well as improving their memory since students are physically active while engaging with concrete manipulatives (Hartshorn & Boren, 1990; McNeil & Jarvin, 2007).

Manipulatives have been used as a mathematical tool from the past to now (Thopmson, 1994). Boggan et al. (2010) stated that ancient Southwest Asians generated counting boards and the ancient Romans used the abacus. These could be considered as examples of use concrete manipulative in mathematics in the early date. In addition, concrete manipulatives such as pattern blocks were started to use especially in kindergarten education at the beginning of the 1800s (Boggan et al., 2010); however, concrete manipulatives have been used in teaching and learning mathematics more commonly especially since the 1900s. NCTM (2000) has supported the use of them to provide learners building conceptual understanding by the means of a wide range of visual representations. Using concrete manipulatives in mathematics lessons facilitates students to construct their learning processes in more meaningful ways when compared to traditional methods. They can be considered as one way to support students' interest in geometry (Sherman & Bisanz, 2009). Furthermore, teacher education textbooks encourage teachers to use manipulatives during mathematics instruction (Van de Walle, 2004).

Many researchers such as Piaget (1970), Fennema (1972), Sowell (1989), Bruner (1966), Skemp (1987), Boling (1991), Clements and Battista (1990) and Thompson and Lambdin (1994) mentioned that learning process of students should begin with concrete experience before passing through abstract thought. To illustrate, extensive cognitive improvement theory was introduced by Piaget. According to this theory, the cognitive developmental consists of four stages: sensorimotor, preoperational, concrete operational and formal operational. Sensorimotor stage is monitored between 0 and 2 ages and children explore their environments with the aid of their motor skills and senses in this stage. This exploration starts with their bodies. Children have a curiosity about everything in their environments. The pre-operational stage is observed between 2 and 7 ages. In this stage, egocentric thinking is monitored on children. Although thinking is based on the non-logical way, it is noticed that children' memory, both conservation and languages skills are developed (Huitt & Hummel, 2003). The concrete operational stage begins with age around 7 and lasts until ages 11. In this stage, children associate concepts and symbols with concrete objects. For this reason, the use of concrete manipulatives is suggested in this stage (Fennema, 1972). Children had operational thinking and reversible mental actions (Huitt & Hummel, 2003). Egocentric thinking is decreased. Children have a conversation of number, liquid, length, area, mass, weight, volume (Huitt & Hummel, 2003). The formal operational stage begins with adolescence and lasts until adulthood Children have some skills such as abstract reasoning and logically thinking. Children associate symbols with abstract concepts (Huitt & Hummel, 2003). According to Piaget, students should be engaged with concrete manipulative especially before passing through abstract thinking. In this way, they can be more proficient in learned topics. In other words, learned topics make more sense to students. Similarly, Bruner mentioned that learning information consists of three different stages: enactive (concrete), iconic (pictorial) and symbolic (abstract). The enactive stage has been observed ages between 0 and 1. A baby has gained information through action based behaviors. Movements and actions have played crucial roles in this process. The iconic stage is observed between 1 and 6 ages. Learning occurs with the aid of using pictures and models and pictorial representations gain an important role in this stage. The symbolic stage is observed age around 7 and onwards, and children learn information with the aid of using languages and abstract symbols. Bruner suggested that students gain experiences through pictorial and concrete objects firstly. Then, symbolic activities should be passed to reach more effective learning. Similar to Bruner, Fennema (1972) mentioned that mathematical manipulatives should be used in education to create an environment where students express their mathematical ideas through physical objects.

In conclusion, many educators supported that students should be familiar with concrete manipulatives before passing abstract representations of mathematical concepts (Uttal, Scundder & Deloache, 1997). Using concrete manipulative might enable learners to gain mathematical concepts and their logic in more meaningful ways (Vinson, et al., 1997). Moreover, the results of many studies have supported the idea that using concrete manipulatives in mathematics instruction has a positive effect on students' success (Cankoy, 1989; Carbonneau, Marley & Selig 2012; Gürbüz, 2010).

Gürbüz (2010) conducted a study to compare the effects of activity-based instruction and traditional instructions on students' conceptual development of certain probability concepts. These activities included using of concrete manipulative and materials. A pretest–posttest control group design was implemented with 80 seventh graders. 'Conceptual Development Test' was applied to all groups before and after the treatments. ANCOVA was preferred for the analysis of data. The result of the study showed that activity-based instruction has a significantly greater effect on the development of probability concepts of seventh-grade students.

Furthermore, Cankoy (1989) conducted a study to evaluate eight grade students' achievement on probability topic of students who are exposed to traditional and mathematics laboratory based (concrete model usage) mathematics instruction. 73 eighth grade students joined the study. There existed control and experimental groups. The results demonstrated that success of the experimental group was statistically higher than the control group.

Moreover, Charbonneau, Marley, and Selig (2013) conducted a systematic literature review to evaluate the effect of using concrete manipulative during mathematics instruction. This analysis included 55 studies. This study included one control and one experimental group. A various grade level of students attained the study (N = 7237). The results showed that the use of manipulative when compared with the instruction that only used abstract math symbols had statistically significant effect.

In addition, Sowell (1989) analyzed 60 studies to evaluate the effect of manipulative based instruction on students' success. Students from different grade levels participated in the study. Analysis of studies showed that students who used concrete manipulatives for a long time displayed better performance based on post test scores when compared to students who did not use concrete manipulatives. For this reason, it should be given enough time for students to conceptualize experiences through an interaction with concrete manipulative and the using concrete materials should be adopted into as many mathematics topics as much as possible.

Even though many types of research and ideas have supported using concrete manipulative, several studies have shown that the use of concrete manipulatives does not always increase the success of students (e.g. Ball, 1992; Moyer, 2001; Thompson, & Lambdin, 1994). Ball (1992) stated that “although kinesthetic experience can enhance perception and thinking, understanding does not travel through the finger and up the arm” (p. 47). One of the reasons can be considered as teachers’ content knowledge since Moyer (2001) stated that content knowledge of teachers played a crucial role while using and integrating concrete manipulative into in their lessons. If teachers do not have the adequate content knowledge about how to integrate concrete manipulatives into mathematics lesson and used them unconsciously, the usage aim of the manipulatives is not grasped by students and they may behave them like toys. Before students start using concrete manipulatives in learning mathematics concepts, it should be explained to students why concrete manipulatives are used to teach and to learn such a concept (Burns, Van DerHeyden, & Jiban, 2006) since Thamson (1994) stated that use of concrete manipulatives should make sense mathematical meaning for students. The second reason can be considered as instructional environments that concrete manipulatives should be used effectively. Teachers should use them in their lessons properly and learning environments in which students transform concrete experiences to abstract understanding and make connections among mathematical concepts should be created (Cooper, 2012). Intention of teachers about use of concrete manipulatives and the perception of students should be coincided with each other (Thomson, 1994). In addition, Burns and Hamm (2011) conducted the study to compare the effect of concrete manipulative and virtual (computer-based) manipulative on teaching fraction concepts in third grade and the introduction of symmetry concepts in fourth grade. 91 third grade students and 54 fourth grade students join the study. Students were randomly assigned to the class in which either concrete or virtual manipulative was used. A pretest–posttest design was implemented. The result of the study showed that even though both groups displayed the improvement during the treatments, there was no statistically significant difference in the pretest and posttest scores of third graders’ fraction knowledge. The similar result was valid for fourth-grade students’ success.

To sum up, it is generally seemed to be a common idea the use of concrete manipulatives in mathematics lessons to increase the effectiveness of lessons (Thomson, 1994). There are different types of concrete manipulatives such as cousinaire roods, geoboards, geometry tiles, and tangrams which are used to facilitate students’ attitude towards mathematics positively and to improve students’ success. In this study, geoboards and geometry tiles were utilized since they are easily accessible and to be designed as a teaching and learning tool in geometry education (Williams, 1999). They provide an opportunity to teach many mathematical concepts such as reflection, translation, rotation, pattern, both identifying area and perimeter of quadrilaterals for all students with different grade levels. Use of concrete manipulatives makes it convenient to students, especially with difficulty on drawing shapes, while constructing and examining the properties of shapes and images (Carroll, 1992). In addition, they can be utilized in different learning settings such as discovery learning, collaborative learning, investigational based learning, and problem-based learning. Students may construct more conceptual understanding through using concrete manipulatives. Scenes from geoboard and geometry tile are respectively indicated below.

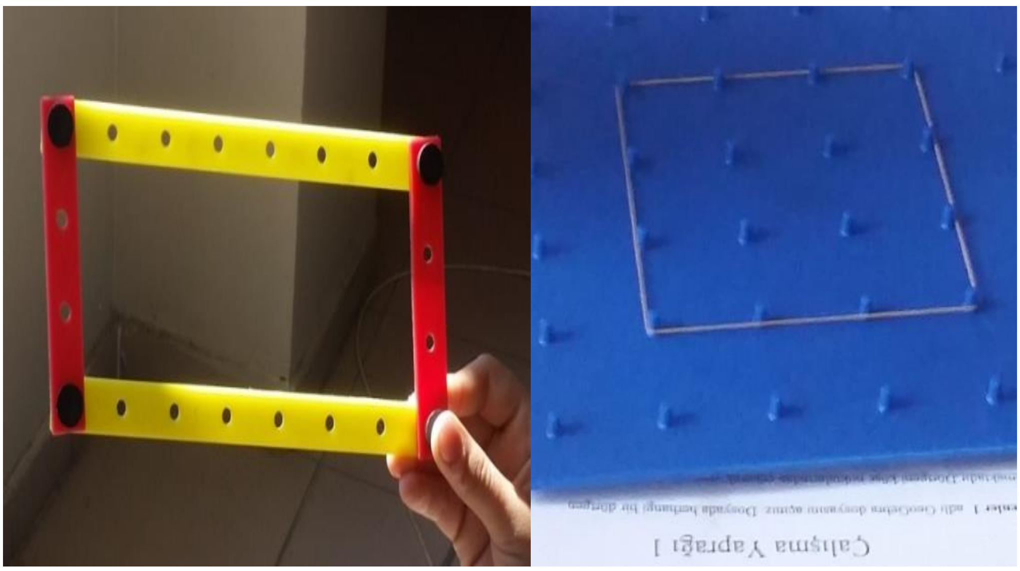

Figure 1 Scenes from geometry tiles and geoboard respectively

2.2 Place of Technology in Geometry Education

The demand on using technology is increasing day by day since it has been inevitable parts of people's lives in many areas from engineering to art. Consequently, the use of technology has also been integrated into education since it supports learning of students and help students to reach important mathematical topics and ideas (Hollebrands, 2003). One of the reasons to integrate technology in education can be said that used traditional instruction methods do not satisfy all the expectations from students in this era (Alakoç, 2003; Aktüment, & Kaçar, 2003) since types of instruction play an important role while teaching and learning geometrical concepts (Fuys, Geddes, & Tischler, 1988). With the aid of computer technology in education, teachers have adapted their instruction and teaching methods with multiple ways that provide students to gain different perspectives (Dick & Hollebrands, 2011). With the integration of computer technology in education, which can be called as a new dimension of teaching mathematics, the lessons are redesigned more student-centered, and students are encouraged to have critical thinking skills such as reasoning, exploring, problem-solving (Jaber, 1997). Instruction, which is supported by technology, enables students to construct their own knowledge, to grasp and to visualize mathematical concepts much better than compared to traditional geometry lessons (Heid, 1997). In addition, the National Educational Technology Standards for Students (NETS, 2008) gave importance to integrating technology into both teaching and learning of mathematics processes. NETS (2008) stated following standards in terms of integrating technology into education:

- identify, use, evaluate, and promote appropriate technologies to enhance and support instruction and standards-based curriculum leading to high levels of student achievement.
- facilitate and support collaborative technology-enriched learning environments conducive to innovation for improved learning.

- provide for learner-centered environments that use technology to meet the individual and diverse needs of learners.
- facilitate the use of technologies to support and enhance instructional methods that develop higher-level thinking, decision-making, and problem-solving skills (p. 258).

Similar to NCTM, Laborde, Kynigos, Hollebrands, and Strasser (2006) emphasized that technology can be showed how much the tools shape the mathematical activity and led researchers to revisit the epistemology of geometry" (p. 29). Laborde, Kynigos, and Strasser (2006) examined the effects of using different technologies in geometry education and common areas of used technology in geometry education are classified as triangles, quadrilaterals, geometric transformations, and measurements of areas.

There have been numerous studies that show integrating technology in education has a positive effect on students' learning process (e.g. Hollebrands, 2003; Koehler, & Mishler, 2005; Laborde, Kynigos, & Strasser, 2006; Preiner, 2008; Ubuz, Üstün, & Erbaş, 2009). It can be generally integrated into education through technological tools such as a computer, smart boards, graphing programs, spread sheets, various types of computer software programs such as Dynamic Mathematics and Geometry Software. Dynamic Geometry Systems (DGS) is one of the most common preferred computer applications in geometry education in Turkey. Moreover, current mathematics curriculum encourages teachers to design their instructions with using dynamic mathematics software (MoNe, 2013).

Dynamic Geometry Software (DGS) are computer software programs which enable users to make geometric constructions, manipulate these constructions and measure some properties of constructed shapes such as interior angles, and the length of sides on the computer screen (Goldenberg, & Couco, 1998). This implies that even if the image of a geometric shape is changed, the relationship of this shape is conserved. These are provided thanks to three important features of Dynamic Geometry Software: drag mode, macro-constructions, and locus of points (Sträßer, 2002). A dragging feature makes different dynamic geometry software from traditional geometry instructions with the aid of constructing a bridge between the conceptual realm of mathematical entities and the world of virtual empirical objects (Arzarello, Micheletti, Olivero, Robutti, Paola & Gallino, 1998; Sträßer, 2002). Thanks to the dragging options, the construction of figure exposed to transformation through saving their basic properties (Leung & Lopez-Real, 2002). Macro-construction means consolidating countless complex structure with the help of a one mouse click (Kadunz, 2002). More specifically, Kadunz (2002) defined the macro function as "programming by example" (p. 74). Jahn (2000) defined a locus of point such that "in the context of synthetic and static geometry, a geometric locus is likely to be perceived as a set of points satisfying a certain property, the set being regarded either globally, or point by point" (p. 127). Thanks to these properties of Dynamic Geometry Software programs, students get a chance to construct figure easily. In addition, Harpell and Harwell (2010) stated that DGS promotes students' learning and enhances students' perspective. For this reason, it can be considered as an effective mathematical tool which supports students' learning. Similarly, Hollebrands (2003) stated that DGS gives students an opportunity to alter the view of constructed shape which is supported by dynamic movements when the relationship and properties on the figure are kept. Moreover, students get a chance to both construct objects and observe these geometrical constructions in terms of different perspectives of them (Bowden & Marton, 1998; Aarnes & Knudtzon, 2003). Dynamic geometry software is a tool which provides students with observing and constructing with geometrical objects and their relationships (Healy & Hoyles 2002).

There are many studies conducted in geometry education to investigate the effects of the usage of dynamic geometry software on students' learning (e.g. Akgül, 2014; Erbas, &Yenmez, 2011; Furner & Marinas, 2006; Hollebrands, Conner, & Smith, 2010; Healy & Hoyles, 2002; Isıksal & Askar,2005; Pilipezuk, 2006; Samur, 2015).

Pilipezuk (2006) investigated the effects of graphing technology on pre-algebra students' understanding of function concept. A quasi-experimental design was preferred, in which experimental group students were exposed to five Calculator-based laboratory activities while the control group students were not exposed to any of these activities. Pre-test and post-test were applied as a data collection instruments. Moreover, the data were analyzed by using both quantitative and qualitative methods. Quantitative results showed that there were no significant differences between groups in terms of modeling, graphing and problem-solving. However, qualitative results indicated that experimental group students were more successful than control group students on graphing a function, scaling and demonstration of the local and end behavior of a function. Pilipcezuk (2006) concluded that Calculator-Based Laboratory activities had a positive effect on the students' performance.

Hollebrands, Conner, and Smith (2010) conducted research to examine students' arguments about geometric objects and relationships in hyperbolic geometry research with the help of using dynamic geometry tool. In a college level, eight students joined that study through a task-based interview. These interviews were based on investigating the properties of quadrilaterals. Three themes were identified after analyzing interviews. These themes are as follows: the explicitness of warrants provided, usages of technology, and types of tasks. The first theme was related to the fact that if students reached a solution to the problem, they do not prefer using any technological tool. This was generally realized during proof and justification process. Otherwise, if students got an idea about the solution of the problem, they preferred it to get a diagram on the screen. The second theme was explained that the technology was generally preferred to produce new information through dragging and measurement tool. The last theme was related to the idea that if students used technology to confirm their claim, they had doubts about their idea and used technology to support their claims or ideas.

Healy and Hoyles (2002) researched the problem-solving process by using dynamic geometry software. Successful students' responses showed that dynamic geometry tool affects students' both scaffolding and logical deduction process. It affected successful students' perspective positively. On the other hand, less successful students did not reach the goal even if they used the dynamic geometry software during the treatment.

Isıksal and Askar (2005) examined the effect of dynamic geometry software and spread sheet on students' mathematics achievement and mathematics self-efficacy on 7th-grade students. While an experimental group was exposed to Excel and Autograph based instruction separately, a control group was exposed to traditional-based instruction. The result of the study showed that the mean scores of Autograph groups had significantly greater than the mean scores of traditional groups. On the other hand, there was no significant mean difference between the groups instructed with Autograph and Excel and between the groups instructed with Excel and Traditional groups with respect to mathematics self-efficacy.

Moreover, Samur (2015) conducted a research to observe the effect of using dynamic geometry on 8th-grade students' success, attitudes toward geometry and technology when it was compared to traditional instruction. While an experimental group was exposed to dynamic geometry based computer instruction, a control group was exposed to traditional-based instruction. The result of the study showed that dynamic geometry based computer instruction had a significant effect on not only students' success in geometry and but also their attitudes towards geometry.

Baki and Köse (2009) examined the effects of dynamic geometry software and physical manipulatives on the spatial visualization skills of first-year pre-service mathematics teachers. A quasi-experimental design was preferred. There were three treatment groups. The first group was instructed with Dynamic Geometry Software (DGS) Cabri 3D while the second group was instructed with physical manipulative. In addition, the control group was instructed with traditional methods. The result indicated that success of students who were instructed with DGS outperformed than the students instructed with the physical manipulative.

In addition, Akgül (2014) examined the effects of instruction supported with Dynamic Geometry on 8th-grade students' achievement in transformation, geometric thinking, and attitudes toward mathematics and technology compared to the traditional instruction. The results supported to design instructions based on used dynamic geometry software according to results of students' mathematics achievements in transformation geometry.

Furthermore, Toker-Gül (2008) conducted a study to examine the effects of using dynamic geometry software while teaching through 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 results of the study showed that using dynamic geometry software improved teaching environment with guided discovery method and it had a positive effect on students' geometry achievement.

In addition, Souter (2001) conducted a study to investigate the effect of technology-based instruction with respect to students' academic achievement on algebra topic. For this study, control groups were instructed with traditional methods and experimental groups were supported with technological instruments. 92 ninth-grade students joined the study. It was concluded that according to the result of students' responses, technology supported lesson increased students' success.

According to the result of these studies, it was concluded that using the dynamic software in mathematics and geometry lessons has a positive effect on students' success. On the other hand, Hudnutt and Panoff (2002) mentioned that some teachers do not prefer using technology in their lessons since they have thought that the same message can be conveyed without using the technology. Similarly, some studies have indicated that using technology in classrooms does not have enough effects on students' success.

For example, Şimşek and Yücekaya (2014) examined how utilizing 3D dynamic geometry software in teaching geometry and assessment learning domains of Prisms unit of the 6th grades' mathematics lesson affects their spatial ability. The results showed that there is not any statistically significant difference between the experimental and control group students' performance in terms of spatial ability. Moreover, Kurak (2009) examined the effects of using DGS on students' understanding levels of transformation geometry and their academic successes. The results implied that achievements of students in transformation geometry were not significantly different from each other. It is important to use such an instructional tool appropriately.

In addition, Ubuz, Üstün, and Erbaş (2009) investigated the effects of instruction using a dynamic geometry environment to traditional lecture based instruction on seventh-grade students' learning of line, angle, and polygon concepts. The results showed that using dynamic geometry software in education has positive effects on student' achievement and enhances students' ability to analyzing, conjecture, reasoning and exploring the mathematical concepts.

In the light of all these studies, it can be concluded that using dynamic geometry software has a positive effect on learners' success and to enable students to learn by doing. In this way, students can discover properties of constructed shapes individually and they do not have to memorize the properties of geometrical shapes.

2.2.1 GeoGebra and Its Effect on Students' Achievement

There are types of Dynamic Geometry Software such as Geometric Supposer, Geometer Sketchpad, Cabri 3D, and GeoGebra. GeoGebra is preferable among these because it is easily accessible, free, and supported with multi language options (Akgül, 2014). GeoGebra is designed to learn and teach mathematics and combines some basic properties of computer algebra system with a different subject area of mathematics such as algebra, calculus, and geometry (Hohenwarter & Preiner, 2007). GeoGebra provides users to observe multiple presentations of a mathematical concept, and topics via its different views such as algebraic, graphic and spreadsheet (Hohenwarter & Jones, 2007; Lavicza et al., 2009). Žilinskiene and Demirbilek (2015) mentioned that "it allows educators to create an interactive learning environment to foster experimental and discovery learning for students while visually interacting with geometry, algebra, and calculus, graphing and statistics" (p. 1). A screenshot of GeoGebra is shown below in Figure 2.

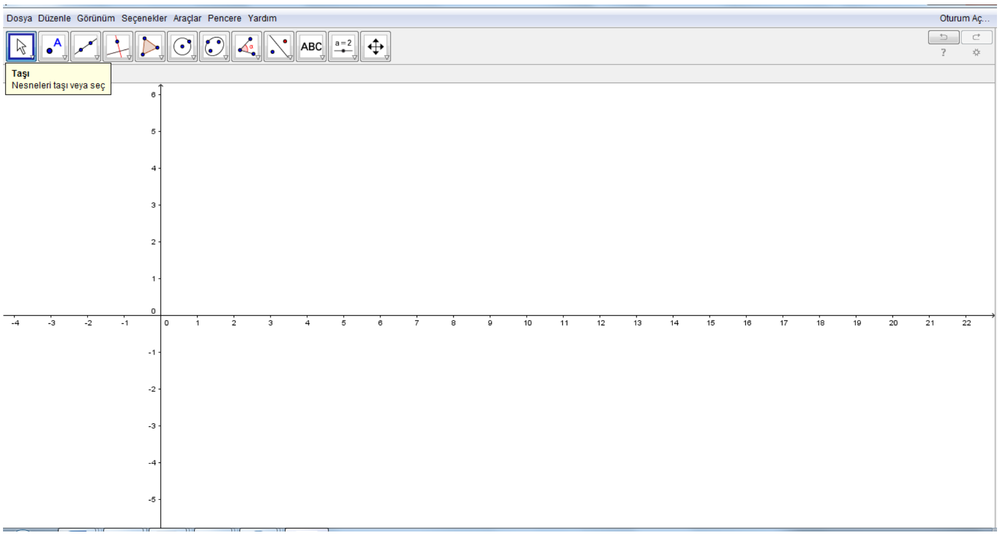

Figure 2 A screenshot from GeoGebra screen

Moreover, thanks to the usage of this software, all properties of original constructions and their relationships are preserved (Lehrer & Chazan, 1998). In addition, GeoGebra enables international users from all around the world to share their activities and teaching materials with one another. Its usage is easy since users can personalize its properties such as font size, color, and language and students get a chance to visualize ideas and make a connection between geometry and algebra (Hohenwarter & Jones, 2007). By the help of using GeoGebra, the student-centered learning environments in which students participate actively in lessons are created. In this way, GeoGebra enables students to create discovery learning through interactive explorations, experimental learning, and collaborative learning through discussing with classmates (Diković, 2009; Preiner, 2008). Furthermore, GeoGebra gives the users an opportunity to explore the properties of constructed figures, to make a connection among mathematical relations, to manipulate figures, and to use for geometric transformations in teaching geometry (Jones, 2000).

Numerous studies were conducted to investigate the effect of GeoGebra on students' academic achievement (e.g. Mehdiyev, 2009; Ozçakır, 2013; Saha, Ayub & Tarmizi 2010; Zengin, Furkan & Kutluca, 2012). Meydiyev (2009) examined the effects of GeoGebra software with the number of 20 in terms of learning geometry with ninth grade students. Observations, pre-test and post-test, and interviews were preferred to collect data. The result of the study showed that after treatments, students had a positive attitude and were motivated towards GeoGebra based geometry education.

Zengin, Furkan and Kutluca (2012) investigated the effects of using dynamic mathematics software called GeoGebra on tenth-grade students' achievements in trigonometric functions. They constructed two groups one of which was an experimental group instructed with GeoGebra (*N*=25) and the second one was control group instructed with traditional geometry education methods (*N*=26). The results of the study showed that there was a significant difference between the groups since the experimental group instructed with GeoGebra was more successful than the control group instructed with traditional methods.

Similarly, Saha, Ayub, and Tarmizi (2010) conducted a study with 53 secondary school students to examine the effects of GeoGebra in learning of Coordinate Geometry in terms of mathematics achievement. The Spatial Visualization Ability Test was applied to students at the beginning of the study and the sample was categorized into two groups as high visual-spatial ability students (HV) and low visual-spatial ability students (LV) based on the test result. Two groups were constructed. One group was instructed with GeoGebra and the other group was instructed with traditional methods. The result showed that there was a significant difference between the GeoGebra group and control group in terms of mathematics achievement. Instructed with GeoGebra group had higher post test scores.

Ozçakır (2013) investigated the effects of mathematics instruction supported by dynamics geometry activities called GeoGebra on students' achievement in the area of quadrilaterals and students' achievements according to their van Hiele geometric thinking levels. 76 seventh grade students participated in the study. Experimental and control groups were formed. While the experimental group was instructed with GeoGebra supported activities, the control group was exposed to traditional instruction. The results showed that students in the experimental group were significantly more successful than students in comparison group when the students were on the second level of van Hiele geometric thinking according to posttest result.

In the light of these studies, it can be concluded that GeoGebra is a beneficial tool for students in mathematics and geometry education.

2.3. Quadrilaterals and Studies Related to Its Definition

"Geometry and Measurement" can be defined as one of the content areas in mathematics (MoNE, 2013). In addition, geometry teaching develops visualization, spatial thinking skills, proving and deductive reasoning of learners (Battista, 2007). Fujita and Jones (2007) stated that definitions determine the properties of mathematical objects; for this reason, the definitions have a big place of geometry education to enable students to construct meaningful understanding. To put it differently, the definition of important attributes of objects is a crucial issue since it grounded on students' conceptual understanding (Erez, & Yerushalmy, 2006; Poincare, 1914). Furthermore, the definition of quadrilaterals is linked to the classification of quadrilaterals (Fujita, & Jones, 2007); however, the definitions of quadrilaterals are one of the difficult issues in geometry education due to structural complexities of them (Fujita & Jones, 2007; Vinner, 1991; Zaslavsky, & Shir, 2005). Quadrilaterals and their definitions are mainly grounded on their hierarchical relationship. The mathematics curriculum is generally focused on improving the relationship among geometric shapes by considering their basic properties (Özçakır, 2013). Van Hiele (1999) suggested a hierarchal model based on levels related to geometry learning of students, which might help educators to observe students' behaviors and thoughts in geometry education. It consisted of five levels. Students can recognize geometric shapes based on their visual experience at level 1. Then, when students have reached the Level 2, students begin noticing the properties of geometric shapes based on their descriptive and analytic thinking and they can classify geometric shapes according to shapes' minimal features. At level 3, it was expected forms students to make an informal and relational deduction and recognize the relationship among objects. At level 4, students make a formal inference and at level 5, students understand the axiomatic systems in geometry. In Turkey mathematics curriculum expects 5th-grade students to reach at Level 3 and consequently to classify geometric figures and objects based on considering their basic properties (MoNE, 2009a). MoNE (2013) defined that there is the hierarchical relationship among quadrilaterals which requires logical deduction and it is expected from 5th-grade students to define classify quadrilaterals according to their basic properties. A quadrilateral means a four-sided polygon with four angles. Although there are many types of quadrilaterals, the most common five types of quadrilaterals accepted in 5th-grade mathematics curriculum in Turkey: square, rectangle, rhombus parallelogram, and trapezoid. Usiskin and Griffin (2008) stated that there are two different classifications of quadrilaterals based on the acceptance of the definition of trapezoid since some disagreements about a definition of trapezoid exist (Usiskin and Griffin, 2008). Firstly, it is accepted as exclusive definition such that “A type of quadrilateral with exactly one pair of parallel sides is called as a trapezoid”. According to this definition, parallelograms and trapezoids have not been ordered hierarchically called as partition classification of quadrilaterals (De Villiers, 1994). Such classification assumes that various subsets of concepts are disjoint from one another. Figure 3 below summarizes this hierarchical classification of quadrilateral based on the exclusive definition.

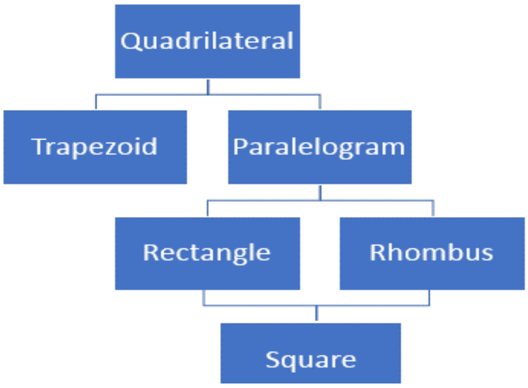

Figure 3 The classification of quadrilateral based on exclusive definition

Secondly, it is accepted as an inclusive definition such that “A type of quadrilateral with at least one pair of parallel sides is called as a trapezoid”. According to this inclusive definition, parallelograms are a special type of trapezoid (Usiskin, et al., 2008). In other words, quadrilaterals such as parallelogram, rectangle, square, and rhombus are classified under quadrilaterals title. According to MONE (2013), based on the inclusive definition, the second definition of the trapezoid is valid for objectives of 5th-grade students in the mathematics curriculum. Usiskin and Griffin (2008) classified and defined quadrilaterals in terms of inclusive hierarchical definition as following Figure 4 and 5 respectively.

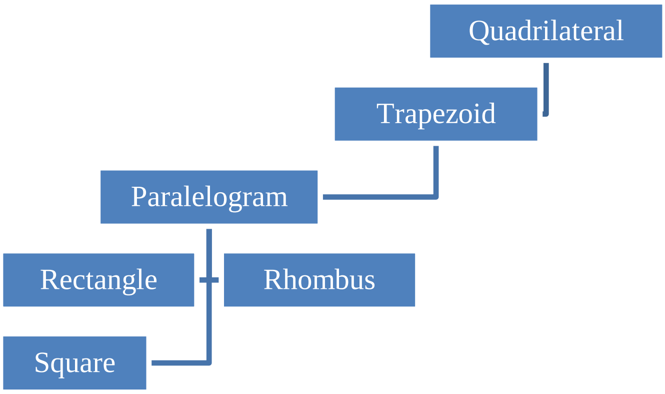

Figure 4 The classification of quadrilateral based on inclusive definition

A trapezoid is a type of quadrilateral with at least one pair of parallel sides.

A quadrilateral with opposite sides parallel and equal length is defined as parallelogram. A parallelogram is a special form of trapezoid.

A rectangle is a type of quadrilateral with opposite sides parallel and equal lengths as well as all angles are equal degree namely 90°. It is called as a special from of parallelogram with right angles.

A rhombus is a type of quadrilateral and its two opposite sides are parallel. The lengths of all sides are equal. It is a special from of parallelogram with equal side.

A square is a type of quadrilateral. Its opposite sides are parallel and equal lengths as well as all angles are equal degree namely 90°. It is called as a special from of both rectangle with equal lengths of all sides and rhombus with right angles.

Figure 5 The definitions of common used quadrilaterals based on inclusive definition

In the light of this hierarchical classification, it is expected from students to improve their logical thinking and interaction between concepts and images of shapes (Fujita, & Jones, 2007). On the other hand, numerous studies have shown that students have generally a contradiction on quadrilaterals' images (Hershkowitz & Vinner, 1983; Burger & Shaughnessy, 1986; Ubuz & Üstün, 2004; Fujita & Jones, 2007). Tall and Vinner (1981) mentioned the reason behind it that definitions of concepts are directly related to the definition of students who construct the structure of quadrilaterals. In this way, students have their definition of concepts. In this point, prototype images play an important role. Hershkowitz (1990) defined prototype images as "all the critical attributes of the concept and those specific (non-critical) attributes that had strong visual characteristics." (p. 82, as cited in Fujita & Jones, 2007) and the prototype definition has a play crucial role in concept image (Fischbein, 1993). When the literature is reviewed, it is observed that definition and classification of quadrilaterals are difficult issues not only for students but also for teachers (Erez & Yerushalmy, 2006; Fujita & Jones, 2007; Monaghan, 2000; Pickreign, 2007).

For example, Fujita and Jones (2007) conducted a study with 263 learners. The aim of the study was to provide a theoretical framing for the researcher of mathematics education, which covered both prototype phenomenon and implicit models in quadrilaterals. The second aim of the research was to report "findings concerning learners' knowledge of the definitions of, and classification relationships between, quadrilaterals." The data analysis showed that learners had a difficulty in understanding of the relationship among quadrilaterals.

Burger and Shaughnessy (1986) conducted interviews with 13 students whose grade levels were different. The aim of that research was to include a description of the van Hiele levels of reasoning in geometry in terms of triangles and quadrilaterals. The tasks used in the study were based on an understanding of students' geometric thinking skills. The analysis of the result showed that students' responses and behaviors were coherent with geometric thinking level of the van Hiele.

Ubuz and Üstün (2004) investigated with three eighth-grade students. They belonged to three different averages: 'above average,' 'average' and 'below average' in terms of mathematics achievement. The observation, interview and the process of interaction between figural and conceptual aspects of identifying and defining the process of polygons, squares, rectangles, and parallelograms were preferred. The result of the study showed that students generally preferred prototypic figures without considering them as exclusive. Moreover, noncritical features of a figure led to difficulties when students identified the concept of these figures. In addition, when students were asked to define own by own, they used both critical and noncritical attributes of the concepts.

In addition to students, Shir and Zaslavsky (2001) investigated teachers' understanding definitions by the means of definition of a square with 20 secondary school mathematics teachers. There existed some statements and asked teachers whether or not they agree or disagree with these statements. They worked individually at the beginning and then they discussed their ideas with a group of students. The result showed that only five teachers accepted all statements. This implied that teachers do not come to agree with the definitions of quadrilaterals.

2.4 Summary of Literature Review

Geometry has secured a big place in school education (Ubuz, Üstün & Erbaş, 2009). It is recommended that teachers use drawings, concrete models, and dynamic software while teaching geometry, as learning environments and materials used in lessons play a crucial role in achieving goals in geometry education. Manipulatives can be defined as a physical object designed to enable the learner to grasp mathematical concepts and properties (Bouck & Flanagan, 2010; Suh & Moyer, 2008).

Moreover, the use of concrete manipulatives in mathematical lessons enables students to construct their own understanding in more meaningful ways than traditional methods (e.g. Cankoy, 1989; Carbonneau, Marley & Selig 2012; Gürbüz, 2010; Stein, & Bovalino, 2001). In addition to the integration of concrete manipulative into education, technological developments have given a chance to educators to restructure educational environments and make teaching and learning mathematics more effective, an argument generally accepted by many researchers.

In addition to the integration of concrete manipulative into education, technological developments have given a chance to educators to restructure educational environments and make teaching and learning mathematics more effective, an argument generally accepted by many researchers (e.g. Borwein & Bailey, 2003; Hollebrands, 2003; Koehler & Mishler, 2005; Laborde, Kynigos & Strasser, 2006; Preiner, 2008; Ubuz, Üstün & Erbaş, 2009).

Technological tools such as computers, smart boards, graphing programs, spreadsheets, and various types of computer software programs, such as the Dynamic Mathematics and Geometry Software, are examples of technologies mainly used in learning settings. Numerous studies have indicated that the use of the Dynamic Geometry Software facilitates students' learning process by helping visualize mathematical concepts and testing the hypothesis process in a dynamic learning environment; this has a positive effect on students' achievement and learning (e.g. Akgül, 2014; Askar, 2005; Christou, Mousoulides, Pittalis & Pitta-Pantazi, 2004; Erbas &Yenmez, 2011; Fahlberg-Stojanovska & Trifunov, 2010; Healy & Hoyles, 2002; Hollebrands, Conner & Smith, 2010; Furner & Marinas, 2006; Pilipezuk, 2006; Samur, 2015). GeoGebra is a type of dynamic geometry software that combines certain main features of the computer algebra system with a different subject area of mathematics, such as algebra, calculus, and geometry (Hohenwarter & Preiner, 2007). GeoGebra enables teachers to construct several types of learning environments, such as collaborative learning, student-centered learning, and discovery learning, owing to its ability to allow experimenting mathematical concepts with the help of its dynamic structure (Preiner, 2008). Many studies have indicated that GeoGebra has positive effects on students' mathematical achievement and learning (Bilgici & Selçik, 2011; Mehdiyev, 2009; Saha, Ayub & Tarmizi 2010; Ozçakır, 2013; Zengin, Furkan & Kutluca, 2012).

The topic of quadrilaterals is one of the core issues in geometry, as it is crucial for almost all grades from preschool to high school education. On the other hand, several studies have indicated that learners have generally a difficulty in quadrilaterals with respect to especially defining and classifying them (Curri & Pegg, 1998; Monaghan, 2000; Pickreign, 2007).

In the light of mentioned studies above, the current study is aimed to investigate how activity-based learning supported by using GeoGebra, and activity-based learning with using concrete manipulative enhance 5th-grade students' learning in quadrilaterals.

CHAPTER 3

METHODOLOGY

This chapter includes basic information about the design of the study, the participants of the study, data collection procedure, the design of the instructions, the instruments used, data analysis, the internal and external validity of the current study, and limitations.

3.1 Design of the Study

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to using activity-based learning only. The other purpose is to gain in depth understanding of the effects of the used materials (GeoGebra and concrete manipulatives) on students' explanations of quadrilaterals through conducting interviews.

A quasi-experimental mixed method research method was used to examine the related research questions. A mixed methods research is the combination of quantitative or qualitative approaches in combination to facilitate a better understanding of research problems than either approach alone (Creswell & Plano-Clark, 2007). Qualitative analysis was used to assess the effects of the used materials (GeoGebra and concrete manipulatives) on students' explanations while defining the properties of quadrilaterals. The quantitative and qualitative analysis completed each other; the quantitative data indicated the differences in students' achievement in the groups whereas the qualitative data examined the reasons for these differences with giving specific examples, sharing their experiences with the treatments. In addition, quantitative data helped the researcher while selecting participants to interview. The following table indicates the overall research design of the study.

Table 1 The Overall research design

The Design of the Study	Mixed Research Design
Quantitative Research Design	A Quasi Experimental Design
Sampling Technique	Convenience Sampling
Data Collection Instrument	Quadrilateral Achievement Test
Qualitative Research Design	Interviews
Data Collection Instrument	Semi Structured Interview Forms

Three classes were included in the study, which were appointed as two experimental and a control group conveniently since there was one computer laboratory in the school. The first experimental group to use GeoGebra was chosen according to the weekly lesson schedule since only the mathematics hour of this class and the vacancy of the computer laboratory coincided. The second experimental group to use concrete manipulatives and the control group to use traditional materials only were selected as experimental and control groups randomly.

In addition, there were the dependent and covariate variables in this study. The dependent variable of this study was the post test scores of students in Quadrilateral Achievement Test. The pretest scores of students in Quadrilateral Achievement Test was used as a covariate in order to control where students started out and increase the accuracy of the result of the study.

3.2 Population and Sample

Convenience sampling method was adopted in the present study. The researcher preferred this public school for the study because she works as a mathematics teacher there, there is a computer laboratory in it, and there is enough number of students for the study in each class. Therefore, it can be said that the sample in this study was favorable. There were three 5th-grade classes at the school arranged at the beginning of the semester by the principal based on the students' 4th-grade academic achievement. The aim was to obtain three classes with similar academic levels. All the students were registered in 5th grade. Their ages ranged from 10 to 11, and they had a low socio-economic status. Many of them did not have a computer at home. However, they took technological courses that provided them with computer literacy. In addition, there were many types of concrete manipulatives in the schools and students got an idea about how to use them in geometry lessons and they learned to use protractor and ruler before the treatment began.

The qualitative part of the study was implemented through semi-structured interviews with three students. Interviews were conducted two weeks after the experiment was carried out. One student was selected from each group according to the following criteria: whether they were talkative, enthusiastic and successful in mathematics classes. The reason for these criteria was to obtain rich data in qualitative part. All lessons and interviews were video-recorded. "Quadrilateral Achievement Test" was applied two weeks before the treatment began and it was given as posttest three days after the treatments were applied. One student was chosen from each class and totally three students participated in the interviews. The interviews were video-recorded. In this way, the inter-rater had a chance to listen to and watch the video recordings to both transcript and interpret students' explanations. All these records were made by volunteerism and permission from the parents of the students.

60 students joined the study in total. 35 of them were girls and 25 of them were boys. Of these 60 students, 19 were registered in the group which used GeoGebra, 20 were registered in the group which used concrete manipulatives, and 21 were registered in the control group. Below, there is a table showing the number of participants with respect to group and gender.

Table 2 The Number of participants with respect to group and gender

Gender	Experimental Group (Activity-Based Learning using Concrete Manipulatives)	Experimental Group (Activity- Based Learning using Geogebra)	Control Group (Activity-Based Learning)	Total
Female	13	10	12	35
Male	7	9	9	25
Total	20	19	21	60

The target population of the study was defined as all 5th-grade students attending public schools in Düzce (a city in Turkey). The accessible population of the study was defined as all 5th-grade students enrolled in one public school because it was not possible to access the target population. The students of three already existing classes (5/A, 5/B, 5/C) at a public school in Düzce were identified as the sample of the present study.

3.3 The Data Collection Instruments

In the present study, both a quantitative and qualitative methodologies were utilized. Quadrilateral Achievement Test and semi structured interviews were carried out as a data collection instruments. All lessons and interviews were video-recorded. The pilot study of Quadrilateral Achievement Test was conducted by the researcher. The developers of the instruments checked the validity and reliability issues of applied tests. These issues were mentioned below.

3.3.1 Quadrilateral Achievement Test (QAT)

To collect data, Quadrilaterals Achievement Test was applied. Questions of this test were adopted from questions from the Van Hiele Geometric Thinking Level Test (VHLT)) and questions in Quadrilaterals and Polygons Achievement

Test. These questions were selected based on the objectives of the 5th-grade mathematic curriculum. VHLT was developed by Usiskin (1982) and was translated into Turkish by Duatepe (2000). Moreover, Quadrilaterals and Polygons Achievement Tests were developed by Genç (2010).

Quadrilateral Achievement Test consisted of twenty-five items. Twenty-one of these items were multiple choices. One of these items was true- false, and four of these items were open ended. The test covered the types of triangles, properties of a triangle, the perimeter of a triangle, identifying properties of parallel lines and line segments, constructing line segments on dot papers, identifying common properties of polygons, area of rectangles, identifying common properties of quadrilaterals, and constructing quadrilaterals on dot papers. Some of those contents were related to 4th-grade topics such as area of squares and rectangles, identifying common properties of squares and rectangles and some of them were related to 5th-grade topics such as types of triangles, properties of triangle, the perimeter of triangle, identifying properties of parallel lines and line segments, constructing line segments on dot papers, identifying common properties of polygons, and properties of polygons. Those items were placed in that study for measuring prerequisite knowledge of students. In VHLT, questions from 1 to 15 (including these numbers) were related to Van Hiele Level 1, 2 and 3. These levels' contents cover 5th-grade mathematics objectives in Turkey.

Quadrilateral Achievement Test which was adopted for this study included eleven items of VHLT. The other 14 items from 12 to 25 (including these numbers) were adopted from Quadrilaterals and Polygons Achievement Test developed by Genç (2010). The rationale for the selection of these instruments called Van Hiele Geometric Thinking Level Test (VHLT) and Quadrilaterals and Polygons Achievement Test were related to measuring variables since the variables and objectives of these instruments were parallel to the intention of the researcher.

The questions of the instruments were analyzed in terms of the relevance on MoNE about the objectives of the quadrilateral unit of 5th grade and the following table indicates the number of these questions.

Table 3 Number of questions in Quadrilateral Achievement Test

Objectives	**Number of Questions**
Students will be able to identify the properties of polygons	Q1, 10 and 14
Students will be able to identify the properties of rectangle, square, parallelogram, rhombus and trapezoid.	Q2,3,4,5,6,7,8,9,11,12,13,14,15,16,17, 18,19,20 and 21
Students will be able to construct the rectangle, square, parallelogram, rhombus and trapezoid on dot paper	Q22,23,24 and 25
Students will be able to interpret the relationship among rectangle, square, parallelogram, rhombus and trapezoid	Q24 and 25

This instrument called Quadrilaterals Achievement Test (QAT) was applied to all groups two weeks before the treatment began. In this way, the researcher got a chance to determine whether the scores of groups were different from each other. QAT was applied as a post-test three days later when the treatments were conducted. Two lesson hours were given to students while they were answering the questions of the test. The validity and reliability issues of Quadrilateral Achievement Test were examined by the developers of the instruments. Nevertheless, the opinions of three teachers who are experienced in their field were checked test with regards to content, language usage in the test, clarity of items and their difficulty level. They agreed on the suitability of the test. The inter-rater coefficients for pilot and main studies were calculated as .96 and. 98 respectively that indicated the reliability of test implementation.

The pilot study of the Quadrilateral Achievement Test was conducted with twenty-three 6th grade students in April 2016. Based on the application of the pilot study, the questions were arranged and two questions were eliminated. Then, 25 items remained. (Appendix A). A rubric (Appendix B) was ready to assess the response of the students in the test.

3.3.2 Interview Form

Semi-structured clinical interviews were implemented with the selected participants. Dunn (2005) stated that semi-structured interview is that some of the questions were planned before the interview began and sub questions occurred during the interviews. In addition, Goldin (2000) stated that clinical interview can be considered as one of the crucial ways of data collection method in terms of evaluating students' mathematical thinking. By the help of interviews, researcher got a chance to give an idea of evaluating effects of used materials on solutions and explanations of students. Interviews were carried out after the treatments. One student was chosen in each class and it was conducted interviews with three students. All students were the female and both pretest and posttest scores of these students were similar to each other.

The interviews took 15 minutes. The external factors such as temperature and noise were minimized by the researcher to standardize the environment for all students. Interviews were audio recorded. In this way, the inter-rater had a chance to listen to and watch the video recording to both transcript and interpret students' explanations. All these records were made by volunteerism and permission from the parents of the students.

3.4 Data Collection Procedure

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to using activity-based learning only. The other purpose is to gain in depth understanding of the effects of used materials (GeoGebra and concrete manipulatives) on students' explanations of quadrilaterals through conducting interviews. This study was implemented over a period of three weeks according to the yearly mathematics lesson plan in the second semester of 2015-2016 education year in a public school in Düzce, Turkey.

For the present study, activity based learning through using GeoGebra was adopted in one of the experimental groups. Activity-based learning through using geoboards and geometry tiles was used with the other experimental group. The control group students had activity-based lessons by using only protractors and rulers. Such experiment was implemented to all groups for 14 lessons, which equals to approximately a time span of three weeks. Each lesson lasted 40 minutes in the school. However, mathematics lessons during the implementation were designed as two lessons together (one block hour) to prevent distraction of students' attention during the activity. If students needed a break for special needs, the necessary permission was given by the teacher.

Based on the lesson plans, the beginning part of the lessons took 10 minutes. The main activity part of the lessons took 50 minutes including activity sheets and both peer and class discussion. Lastly, the closure part of the lessons took 20 minutes. By following the steps on the activity sheets, students in each group built their own learning on quadrilaterals. The teacher, who is also the researcher, took the role of a guide during the lessons, observed students' behaviors and took notes immediately throughout the lessons and activities' implementation process. All classes were exposed to the same activity sheets to attain the same 5th-grade objectives. All the groups did the activity sheets with the same context in the cognitive domain by using different materials. Some questions in the activity sheets were taken from the worksheets developed by Okumuş (2008) for his master thesis. In addition, the quadrilateral topic in mathematics textbooks published by the Turkish Ministry of National Education for 5th-grade students was chosen for the treatment.

While preparing the activities, the important thing was to apply the same activity to each group to investigate the effects of each used material in each class. The only difference was the materials used in each class which are GeoGebra, concrete manipulatives, protractor and ruler.

Firstly, activities were designed according to control group, and then, they were rearranged for GeoGebra usage and concrete manipulative usage. Lesson plans were checked by the other experienced mathematics teacher working at the same school in terms of objectives, content and mathematical language. After his recommendations, the lesson plans were revised. Furthermore, activity sheets in each group were collected from students after each lesson to give feedback to them.

The researcher was also the teacher of all three classes. Therefore, she had the chance to observe the behavior of students in all three classes and tried to create the same learning environment for each class. The other mathematics teacher working in the same school with the researcher attended the lessons of the researcher and checked whether she was biased to any class in terms of learning environments and teaching methods. All the lessons were video-recorded during the implementation process to prevent bias in any groups, so it can be concluded that the researcher treated all the groups equally.

Qualitative data was collected through semi-structured interviews that were conducted three days after the treatment was applied. The aim of the interviews was to investigate the effect of the materials used on students' explanations of quadrilaterals. There was only a piece of paper and a pencil in front of them and students were expected to explain the properties of quadrilaterals. One student was chosen from each class for the interviews purposively in order to receive rich data. The characteristics of those students were similar to each other which are being talkative, enthusiastic and successful. Moreover, their pre and post-test scores were similar to each other. Purposive sampling is supposed to represent the same properties as the whole (Neyman, 1934). The detailed explanations of those students (called Merve, Çiğdem, and Berna) are listed in the results section. A scene can be seen below from one of the interviews.

Figure 6 A scene from one of the interviews

The questions of semi-structured interviews were based on the definition of the properties of the quadrilateral (any quadrilateral, parallelogram, rectangle, square, rhombus, trapezoid) and constructing or drawing an example of these quadrilaterals. During the interviews, the researcher posed sub-questions such as “Why do you think so? Which properties make this quadrilateral different from the other quadrilaterals?, Are there any relations among your constructed shapes?, Can you tell me the properties of this shape?

3.5 The Role of Teacher

The researcher as a teacher worked for two semesters in the school where the study was conducted. For this reason, she knew the students well. The classrooms were arranged by the principal at the beginning of the semester according to elementary grade success to obtain equal degree classes in terms of their academic achievement. As a result, there was no difference in terms of academic performance among the classes before the treatment began.

One of the experimental groups of students examined the quadrilaterals using concrete manipulatives such as geometry tiles and geoboards and answered questions on the activity sheets with the help of these concrete manipulatives. The other experimental group of students examined the quadrilaterals using GeoGebra and answered questions on the activity sheets with the help of GeoGebra. The control group of students examined the quadrilaterals using protractors and rulers and answered questions on the activity sheets with the help of protractors and rulers.

Throughout the study, the same procedures, learning methods, and activity sheets were applied to all groups, and the researcher conducted classes as a teacher for the three classes. The only difference amongst the groups was in terms of the materials used. The teacher always tried to construct activity-based learning environments for all mathematics topics in her lessons. She had a guiding role during the lessons and the students constructed their own learning through observations and both peer and class discussions. Therefore, before the experiment, students were already familiar with activity-based learning, using concrete manipulatives and GeoGebra for many topics of mathematics. Like other topics, activity-based learning was designed to teach quadrilaterals.

The content of the lessons was introduced to the students at the beginning of the lessons in 10 minutes in each class. In addition, some explanations about the activities and expectations from students were emphasized during this stage. 50 minutes were provided for the students to explore the properties of quadrilaterals individually and answer the questions on activity sheets. In this stage, the teacher monitored the students and observed what they did. If students had questions about the activity sheets, the teacher clarified them. The same content, the same activity sheets, and the same learning methods were applied in each class. Students built their conceptual understanding on their own during this stage. After completing their activity sheets, students discussed their findings with their peers sitting next to them. Then, they joined the class discussion.

During this process, the students tried to clarify the properties of quadrilaterals while answering the questions on activity sheets and altogether made a formal definition of the studied quadrilaterals based on their findings. They took notes about the properties of the studied quadrilateral with the guidance of their teacher. At the end of each lesson for 20 minutes, students were provided with the opportunity to make a connection of that lesson's topic with past lessons and daily life experiences, and to generalize their solutions. The teacher assigned the same homework for the following lesson to each class.

3.6 Treatment in the Experimental Groups

This study included two experimental groups. One of the experimental groups' students learned quadrilaterals using GeoGebra while the other group students learned the same topic using concrete manipulatives.

3.6.1 Treatment in Activity Based Learning Supported with GeoGebra

The students learned quadrilaterals using GeoGebra at the computer laboratory in 14 lesson hours. The lessons were designed as one block hour (two lessons together). All students had basic computer skills. For three lessons before the treatment began, the students had been informed about GeoGebra and how GeoGebra was used. There were twenty-two computers at the laboratory and each student had a computer at the lab during the treatment. Activity sheets and GeoGebra files were uploaded to the computers by the researcher before each lesson of the treatment started. The activity sheets were designed to enable the students to explore the properties of quadrilaterals and find the relationship among them by using GeoGebra.

By means of the dynamic structure of GeoGebra, the students made observations and made conjectures among geometric concepts. For instance, the lesson about "The Properties of Parallelogram" began with what they remembered about the general properties of quadrilaterals by asking interesting questions. In this way, the teacher motivated the students towards the lessons. Then, the teacher emphasized her expectations and clarified the procedures that the students would follow in the activity sheets. This beginning stage took 10 minutes according to the lesson plan. Then, the main activity stage of the lessons took 50 minutes. The students opened the GeoGebra file on the computer screen and explored the properties of parallelogram individually with the help of the activity sheets. In this process, they constructed parallelograms in different sizes by dragging slides and measured the length of the sides and angles of each constructed parallelogram. Later, they took notes considering these measurements. They determined which properties enabled the shape to be a parallelogram based on their observations. To put it differently, students observed the similarities and differences among the properties of constructed quadrilaterals shown on the screen and decided in which circumstances a parallelogram was constructed. In this way, the students discovered the properties of a parallelogram on their own. Below is a screenshot from an activity sheet of parallelograms.

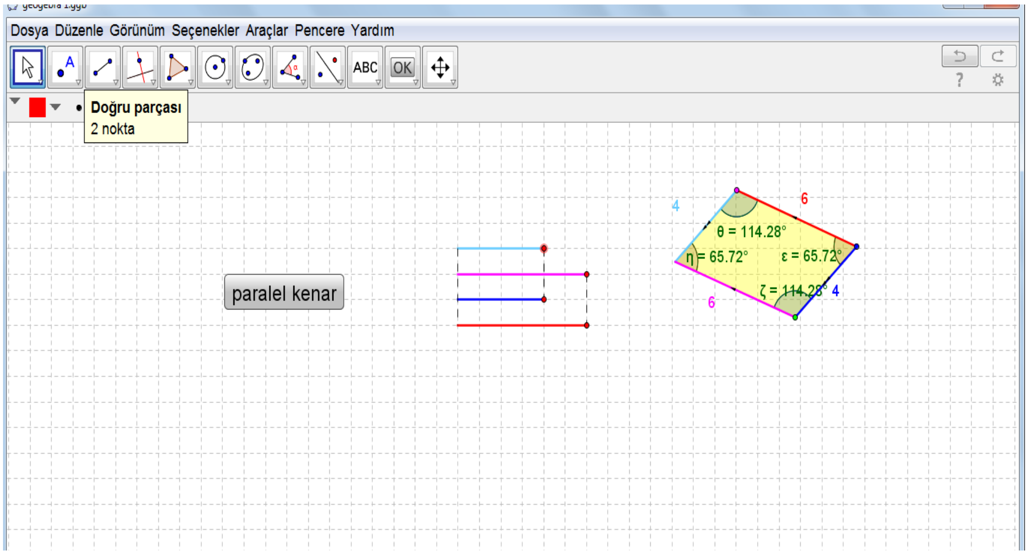

Figure 7 A screenshot from an activity of parallelogram

At the end of the lesson, the teacher asked the students whether or not they observed parallelogram shapes in their daily life, which made a transition to everyday life. The students made a formal definition of a parallelogram and clarified the properties of parallelograms with the help of class discussion and activity sheets and they took them on their notebook. During these stages, students shared their findings with the class. The closure part of each lesson took 20 minutes.

The learning environment was designed to enable learners to construct their own understanding of parallelograms. The students displayed active participation throughout the learning process while they were constructing, exploring, communicating and expressing their ideas on the quadrilateral topic. At the end of the lesson, the teacher asked the students why the quadrilateral is called as "parallelogram". Then, the teacher collected the activity sheets as an assessment of that lesson and gave feedback to students according to their responses and students saved studied GeoGebra files on the desktop by giving them their names. After the lesson, the researcher checked these files to see what they succeeded during the lessons and gave students feedback if it was necessary. The teacher assigned homework to students for the following lesson. There are example scenes from activity-based learning supported with GeoGebra in Figure 8 below and lesson plans used in this group are shown in Appendix C.

Figure 8 Scenes from activity-based learning using GeoGebra

3.6.2 Treatment in Activity-Based Learning Supported with Concrete Manipulatives

In the second treatment group, the students learned quadrilaterals using concrete manipulatives in their regular classrooms in 14 lesson hours. They had an idea about how to use concrete manipulatives such as geoboards and geometry tiles as they had already used them previously for some other mathematics topics such as triangles, and fractions. The revised version of the activity sheets used in GeoGebra classes were used to achieve the same objectives by using concrete manipulatives.

With the help of concrete manipulatives, students made observations more visually, made conjectures among geometric concepts. For instance, the lesson about “The Properties of Parallelogram” began with what they remembered about the general properties of quadrilaterals by asking interesting questions. The aim was to motivate the students towards lesson. The beginning part of the lesson took 10 minutes. Then, the teacher shared her expectations and went over the activity sheets together with the students to clarify the procedures they would follow. The main activity stage of the lesson took 50 minutes and it started with distributing worksheets including examples of several types of quadrilaterals and their name was written on the shape.

By the help of this worksheet, the students constructed these quadrilaterals with geometry tiles and geoboards and observed the similarities and differences among the properties of constructed quadrilaterals. Then, they determined which properties enabled the shape to be a parallelogram according to their observations. They constructed parallelograms in different sizes using geoboards and geometry tiles and measured the length of sides and angles of each constructed parallelogram. Later, they took notes considering these measurements. In other words, the students observed the similarities and differences among the properties of constructed quadrilaterals and decided in which circumstances a parallelogram was constructed. During this stage, the students answered the questions on the activity sheets and discovered the properties of parallelogram on their own. After completing the activity sheets, the students shared their findings with their peers sitting next to them firstly, and then, they joined the class discussion.

The lesson plans had the same content and the same procedure with GeoGebra supported learning. In addition, both this class and the class which used GeoGebra had the same learning environment except for the technology use. The teacher had a guiding role, walking around the classroom and observing students constructing parallelograms. The closure part of the lesson took 20 minutes. At this stage, the teacher asked the students whether they observed parallelogram shapes in their daily life, which made a connection to their everyday life. Students made a formal definition of a parallelogram and clarified the properties of parallelogram with the help of class discussion and activity sheets and they took notes on their notebook.

The learning environment was designed t o enable learners to construct their own understanding about parallelograms. The students displayed active participation during the learning process while they were constructing, exploring, communicating and expressing their ideas on the quadrilateral topic. At the end of the lesson, the teacher asked students why that quadrilateral is called as “parallelogram”. Then, teacher collected the activity sheets as an assessment of that lesson and gave feedback to students according to their responses. The students were given homework for the following lesson. Below are example scenes from activity-based learning using concrete manipulatives in Figure 9 and 10.

Figure 9 Example scenes from activity-based learning using concrete manipulatives

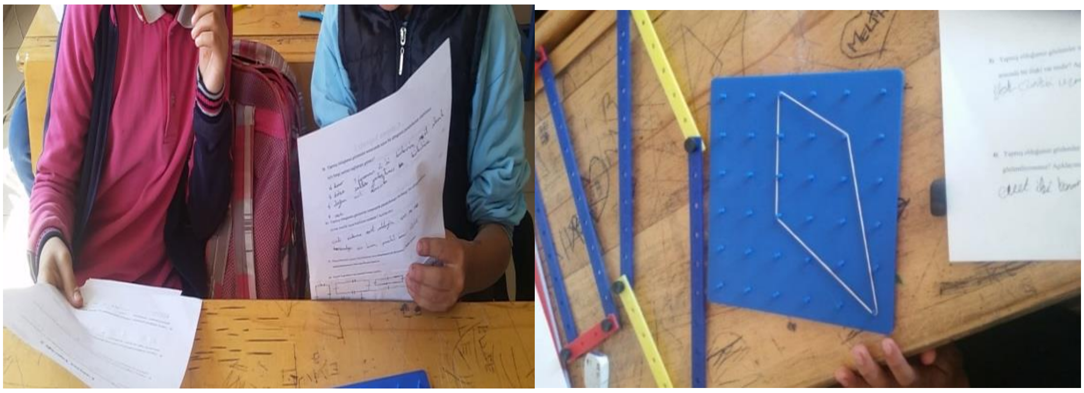

Figure 10 Example scenes from activity-based learning using concrete manipulative

Students constructed their own learning environment through their observations during the experiment. Lesson plans used in this group are shown in Appendix D.

3.7 Activity Based Learning in the Control Group

The lessons with the control group were designed as one block hour (two lessons together) as well. During the treatment, the students used rulers and protractors. Each student carried these materials for all the treatments. Throughout the lessons, the students answered the questions on activity sheets that were the same as the other groups' in terms of concept and content. All of the students in the control group had already known how to construct a line using a ruler and measure angles using a protractor. The same procedure was followed in the control group like in the applied experimental groups. The activity sheets were designed in order to enable the students to explore the properties of quadrilaterals and discover the relationship among them.

The students made observations visually, made conjectures among geometric concepts based on their observations with the help of a protractor and a ruler. For instance, the lesson about "The Properties of Parallelogram" started with the teacher's interesting questions to students regarding what they remembered about the general properties of quadrilaterals. In this way, the teacher aimed to motivate the students towards the lesson. The beginning part of the lesson took 10 minutes. Then, the teacher shared the expectations from the lesson with the students and clarified the procedures that the students were going to follow. The main activity part of the lesson took 50 minutes and in this part, the teacher distributed worksheets that included different types of parallelograms. With the help of this worksheet, the students explored the common points of these parallelograms by measuring angles via a protractor and measuring the length of sides. Then, they took notes of these measurements. Each parallelogram had a different angle and different lengths when compared to others. Then, they determined which properties enabled the shape to be a parallelogram based on their observations. During this stage, the students answered the questions on the activity sheets and discovered the properties of parallelograms on their own. They drew several parallelograms using rulers and protractors.

The lesson plans in the control group had the same content and the same procedure as the experimental groups'. In addition, except for the materials used by the students, the learning environment in the control group was very similar to the ones in experimental groups. During the lessons, the teacher had a guiding role. She walked around the classroom and observed the students while they were drawing parallelograms. The closure part of the lesson took 20 minutes. At this stage, the teacher asked the students if they observed parallelogram shapes in their daily life, aiming to make a connection to their everyday life.

Students made a formal definition of a parallelogram and analyzed the properties of a parallelogram thanks to the class discussion and the activity sheets and they wrote them down on their notebook. Then, the teacher collected the activity sheets as an assessment of the lesson and gave feedback to students according to their response. Students were assigned homework for the following lesson. There are example photos from the class discussion of the activity-based learning group in Figure 11. Lesson plans used in this class are in Appendix E.

Figure 11 Example scenes from class discussion in control group

3.8 Data Analysis

It was preferred quasi-experimental mixed method research method. This model includes a combination of results based on statistical analysis of quantitative data and results based on analysis of qualitative data (Paton, 1990). Both descriptive and inferential statistics were used for quantitative analysis of data. A quasi-experimental design was preferred with two control groups and to be used pre-test and post-test for the present study. Quadrilateral Achievement Test (QAT) was used to collect data as pre-test and post-test for the present study. SPSS 22 was preferred for analyzing the quantitative data.

In descriptive statistics, the mean, median, standard deviation, minimum and maximum test scores, skewness and kurtosis values of the pre-test and post-test scores of the dependent variables were calculated for experimental groups and the control group. Box plots were used to determine the general characteristics of the sample.

Analysis of Covariance (ANCOVA) was preferred to investigate the differences among post test scores of the groups on Quadrilateral Achievement Test with controlling pre-test scores to check inferential statistics. A pretest results were considered as a covariate variable. The significance level to test hypothesis was accepted as 0.05. ANCOVA is used in "experimental studies involving random assignment of units to conditions, the covariate, when related to the response variable, reduces the error variance, resulting in increased statistical power and greater precision in the estimation of group effects". (Keselman, et. al, 1998, p.g.373).

Additionally, qualitative study is conducted to examine students' answers in more detail (Creswell, 2005). Interviews gave a rich description by answering why and how questions about a phenomenon (Yin, 2015). Interviews were conducted two weeks after the experiment was carried out. Three students were selected by using purposive sampling method in order to get more detailed information (Patton,1990). To put it differently, one student was selected from each group according to their being talkative, enthusiastic and successful in order to obtain rich data about the effects of used materials on students' explanations.

Merve, Çiğdem, and Berna participated in the interviews. Merve was from GeoGebra classes. She was an ambitious, successful, tidy and enthusiastic student who wants to learn new things. She was successful in all lessons. Çiğdem was a student from the class where concrete manipulatives were used. She was interested in mathematics, and participated in all mathematics lessons. She was a tidy and successful student. Berna was a student from the control group. She displayed a big achievement in mathematics during 5th grade and interested in mathematics and art lessons. Besides these characteristics, the other thing that they had in common was the fact that they were female since the number of female is more than the number of male.

The interviews were done in the regular classrooms of the students. The aim of such a selection was to make students feel comfortable. In the below, there were tables shown schedule of treatments and interviews respectively.

Table 4 The schedule of the treatments

The Schedule of Treatments	
Creating GeoGebra Activities	First Week of January in 2016
Preparing Lesson Plans	Second Week of January in 2016
Pilot study and Pre-Test Application	First Week of April in 2016
Actual Study	Start 25 April 2016 and Finish 20 May 2016
Collecting Data for Actual Study	23-27 May 2016
Analyzing Data	6-20 June 2016
Interpret Data	1 July -16 September 2016

Table 5 The Schedule of the Interviews

The Schedule of Interviews	
Interviews with Student 1, Student 2, Student 3	1 June 2016 at 16.00-17.30
Interviews with Student 4, Student 5, Student 6	2 June 2016 at 16.00-17.30
Interviews with Student 7, Student 8, Student 9	3 June 2016 at 16.00-17.30
Interpret Data	20 June-5 July 2016

3.9 Internal Validity

Fraenkel and Wallen (2011) mentioned that "internal validity is enable to observe differences on the dependent variable are directly related to the independent variable and not due to some other unintended variable" (p. 166).

Based on this definition, some of the possible internal validity threats such as mortality, subject characteristics, location, testing and implementation, history were tried to be under control for that present study. Since classrooms were constructed at the beginning of the semester by the principal, subject characteristics threat could be removed for the study. In addition, students were at the same grade level and they had an almost same socioeconomic level. Moreover, mortality could not be considered as a threat for the study. At the same time, from three classes 60 students participated voluntarily. Moreover, three classes had same mathematics teacher who was at the same time researcher and they had the regular classrooms at the same time during the 2015-2016 academic year. In addition, all 5th-grade classrooms were on the same floor and they had almost same conditions which eliminate location treatment. For protect validity, the prepared lesson plans were controlled by two experienced mathematics teachers in terms of determining mathematically correct and being appropriate to achieve the objectives.

The interviews were done in the regular classrooms of the students. The aim of such a selection was to make students feel comfortable. Before the treatment, all students and the teacher knew each other. The students were familiar with the usage of concrete manipulatives and GeoGebra during their regular mathematics classes before they learned quadrilaterals topic. Therefore, the researcher did not spend extra time to teach these procedures.

3.10 External Validity

The target population of the study was defined as all 5th-grade students attending public schools in Düzce. Due to not accessing all 5th-grade students in the city, in terms of external validity, the results in the present study cannot be generalized to a larger population. On the other hand, the result can be generalized to a larger population of samples with similar characteristics of the present study. All tests were applied during the students' regular lesson hours in their regular classrooms. There were three classes which have approximately 20 students in each. The physical conditions of three classrooms are similar. For this reason, the threats to the ecological validity were tried to be controlled.

3.11 Limitations

This study is limited to fifth-grade students in a public school in Düzce. Similarly, the number of participants is limited. For this reason, a result of the present study cannot be generalized to the population. The results could not be generalized to other mathematics topics since it was studied an only quadrilateral topic in 5th-grade. Moreover, time was limited with 3 weeks according to the yearly lesson plans during 2015/ 2016 second semester.

CHAPTER 4

RESULTS

The aim of this study was to examine the effects of activity-based learning with using concrete manipulative and activity-based learning with using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to just activity-based learning. The other aim was to gain in depth understanding about effects of used materials (GeoGebra and concrete manipulatives) on students' explanations while defining the properties of quadrilaterals. Qualitative methods such as observations and interviews were conducted to inform forth research question. Quantitative methods got a chance to researcher to compare results among the groups to inform the first,second and fourth research questions. This chapter provides information about both analyses of quantitative and qualitative data to clarify research questions.

4.1 Missing Data

There existed a missing data in the posttest. The student with id number 6 did not take QAT in the group that was provided activity-based learning by using GeoGebra. It was appointed by the mean score of this group to get rid of missing value. The mean score was used instead of missing value since it shows a central tendency of a sample for continuous variables (Pallant, 2011).

4.2 Descriptive Statistics of Pretest and Posttest Result of Quadrilateral Achievement Test for Experimental Groups and Control Group

Descriptive statistics about pretest and posttest results of Quadrilateral Achievement Test for control and experimental groups are represented in Table 6.

Table 6 Descriptive Statistics of Pre-and Post test Results

	Groups	N	Min.	Max.	Mean	S.D	Skewness	Kurtosis
Pretest Result of QAT	CG*	21	12.00	76.50	46.52	18.34	-1.47	-.90
	EG1**	20	18.00	70.50	49.43	15.06	-.38	-.76
	EG2***	19	18.50	82.0	49.97	19.40	.08	-.94
Posttest Result of QAT	CG*	21	25.00	97.00	60.64	19.62	-.12	-.62
	EG1**	20	33.00	96.00	68.76	18.05	-.47	-1.09
	EG2***	19	43.50	98.00	79.61	15.81	.72	-.36

* A control group implemented activity-based learning

**An experimental group implemented activity-based learning with using concrete manipulatives

*** An experimental group implemented activity-based learning by using GeoGebra

Firstly, the pretest result of each group is mentioned in this part. Then, the posttest result of each group is stated. As seen in Table 6, the mean score of pretest for the control group was 46.52 (*SD*=18.34) out of 100. The mean scores for experimental groups that used concrete manipulatives and GeoGebra were 49.43 (*SD*=15.06) and 49.97 (*SD*=19.40) out of 100 respectively. On the basis of these pretest results, it can be said that the mean scores of experimental groups were approximately similar to each other although the mean scores of both experimental groups were relatively higher than that of the control group. According to Table 6, the mean score of the posttest for the control group was 60.64 (*SD*=19.62) out of 100. On the other hand, the mean scores of the posttest for experimental groups that used concrete manipulatives and GeoGebra were 68.76 (*SD*=18.05) and 79.61 (*SD*=15.81) out of 100 respectively. For this reason, it can be said that the class using GeoGebra had the highest mean score among three classes in terms of posttest results. In addition, the mean score of the experimental group used concrete manipulative was higher than the mean of the control group in terms of posttest results.

In addition, the differences among the mean scores were shown in clustered box plot drawn by SPSS 22 according to posttest results of each group. Moreover, it enabled the researcher to determine whether there was any outlier in each group. As it can be seen from box plot, the experimental group by using GeoGebra had the highest mean scores in posttest result of QAT. A box plot is represented in Figure 12.

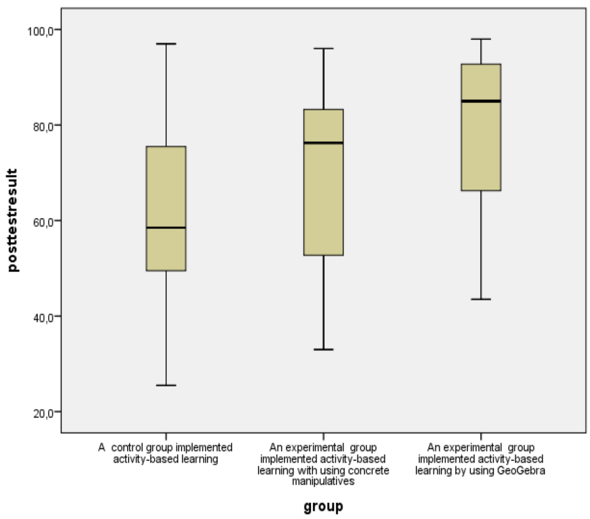

Figure 12 Clustered box plot of the posttest result of QAT

4.3 Inferential Statistics

The researcher attempted to answer the quantitative research questions with using quantitative data. ANCOVA helped the researcher to investigate the mean differences among the groups on the outcome variable, namely posttest scores, with controlling groups' pretest scores. There are some assumptions to be clarified before conducting ANCOVA. The descriptive analysis enabled to the researcher to determine whether the assumptions of ANCOVA was satisfied such as normality assumption.

4.3.1 Determination of the Covariate

Students' previous mathematic success was measured by pretest application of QAT before the treatment. And pretest scores of groups were considered as covariate variable to take a control pre-existing differences among the groups. The correlation between pretest and post-test scores were examined and Pearson Correlation was found as .74. This indicated there was a positive correlation between pretest and post-test results. According to Cohen (1988), this implies that there is a large correlation between the variables if the value ranges between .50 and 1.0.

4.3.2 Assumptions of ANCOVA

There are some assumptions to be needed to clarify before conducting ANCOVA. These were the independence of observations, normality, and measurement of the covariate, the reliability of the covariate, homogeneity of variance, linearity, and homogeneity of regression. Firstly, independence of observations assumption was satisfied since the researcher observed all groups during the implementation of the pretest and posttests and it was finalized that all participants answered their tests individually. Skewness and Kurtosis values of pretest and posttest scores of each class were analyzed to control the normality assumption and the results were shown that it was in acceptable range, -2 and 2, and this showed that they were normally distributed (Pallant, 2007). The values are shown in Table 6. Moreover, histograms of each class normally distrusted shown in the below.

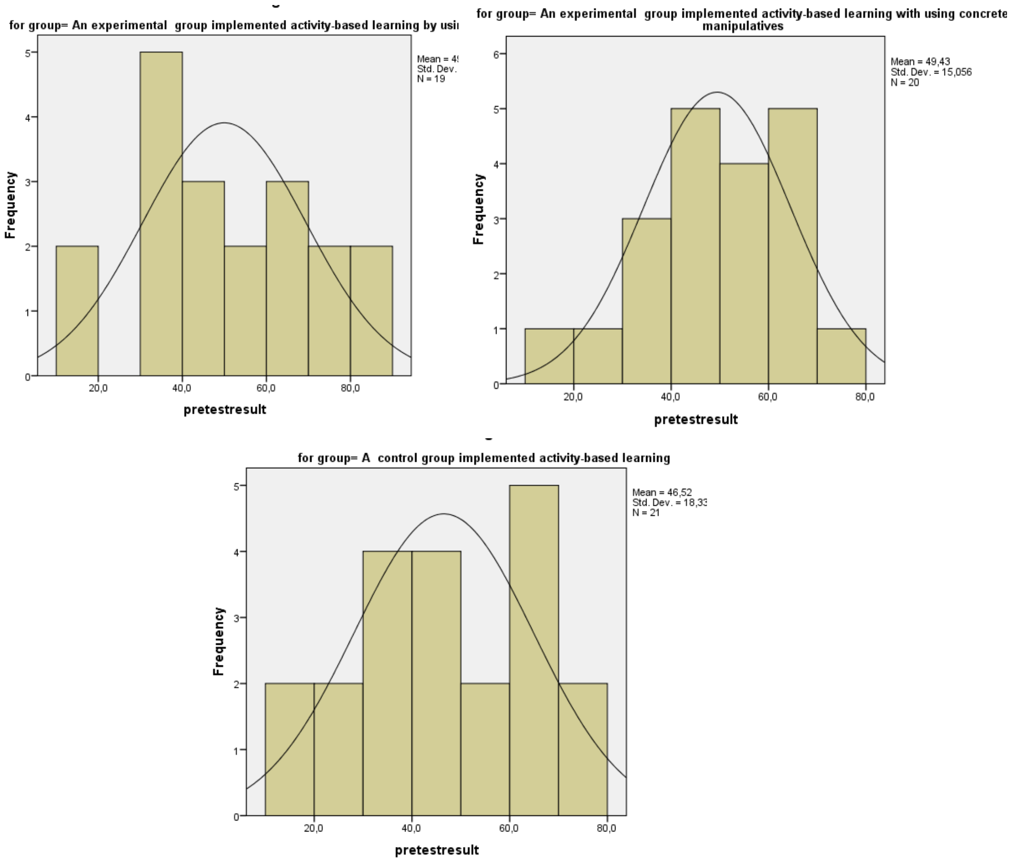

Figure 13 Histograms of the pretest scores of control and experimental groups

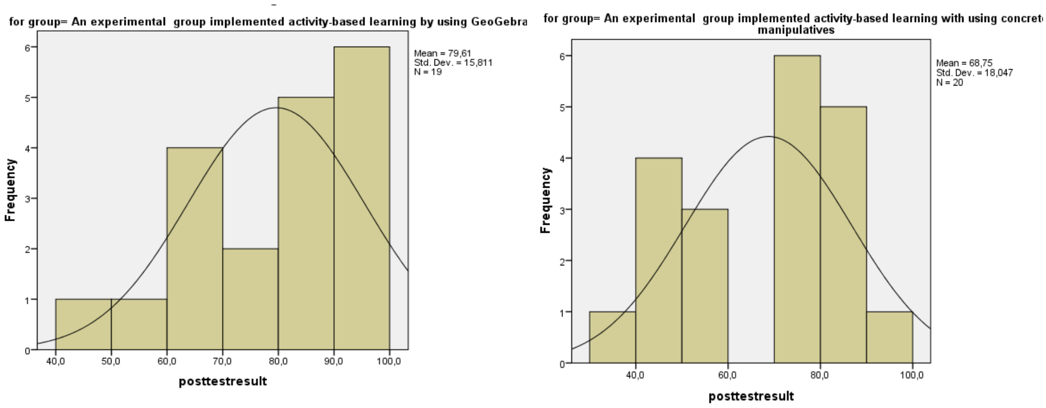

Figure 14 Histograms of the posttest scores of experimental groups

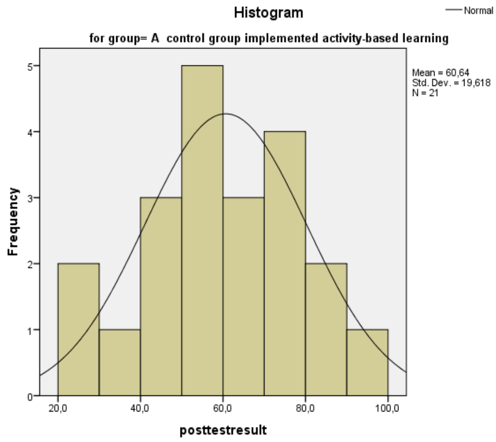

Figure 15 Histogram of the posttest scores of control group

Pretest scores were determined as covariate variable and they were applied to whole groups before the treatments to identify measurement of the covariate.

The reliability of the readiness test as a covariate was calculated as .73. This value is above .70, which implies that the test was reliable.

The homogeneity of variances was checked by Levene's Test of Equality whose result is shown in Table 7. According to this data shown in Table 7, the significance value was greater than .05. As a result of this, the assumption of homogeneity of variance was satisfied.

Table 7 Levene's Test of Equality of Error Variances of Posttest Scores

F	df1	df2	Sig.
1.08	2	57	.35

Scatter plot showed a relationship between the covariate and the dependent variables which enabled researcher to check the linearity assumption. According to scatter plot, it can be concluded that there was a linear relationship between pretest and posttest result that is shown in Figure 16.

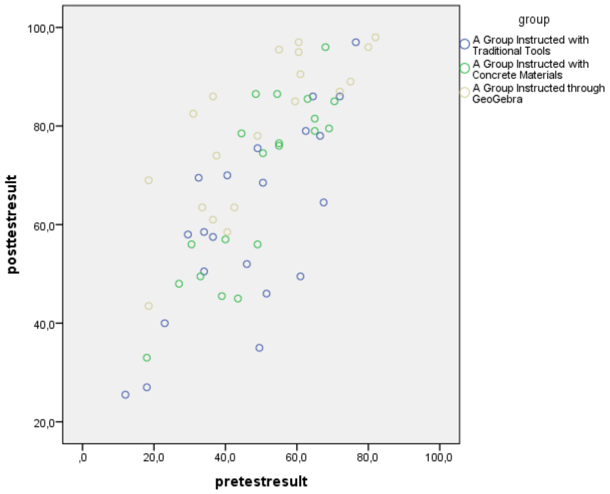

Figure 16 Scatter Plots between Pretest and Posttest

Interaction among the groups and pretest scores was examined in order to check homogeneity of regression assumption. The results are shown on the Table 8.

Table 8 Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	F	Sig.
group * pretestresult	393.85	2	1.56	.22

As it is shown on table, the p value is greater than .05 which means there is no interaction among groups and pretest scores. Consequently, homogeneity of regression assumption was satisfied.

4.3.3 ANCOVA for Main Research Question

Main research question: After controlling students' pre-test results, what is the effect of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals when compared to a control group that was implemented just activity-based learning?

The researcher attempted to answer this question by the help of ANCOVA. Table 9 summarizes the result of ANCOVA.

Table 9 Result of the ANCOVA based on post-test scores

Source	Type III Sum of Squares	df	F	Sig	Partial Eta Squared
group	2660.46	2	10.32	.00	.27
pretestresult	11165.54	1	86.60	.00	.61
Error	393.85	56	1.56	.00	
Total	310548.50	60			

As understood from the table, there was a statistically significant mean difference among the groups that were provided with activity based learning by using concrete manipulatives (*M*=56.25, *SD*=18.40), that were provided with activity based learning by using GeoGebra (*M*= 65.13, *SD*=18.86) and that were provided only with activity-based learning (*M*=60.59, *SD*=23.30) in terms of posttest scores of Quadrilateral Achievement Test, F (2,56)=86.60, *p*=.00, partial eta squared=.27. Partial eta squared showed a medium effect size (Cohen, 1988). To put it differently, 27 percent of the variance in posttest scores was explained by the effect of using GeoGebra in the treatment. This result indicates that the activity-based learning by using GeoGebra had a statistically significant effect on 5th-grade students' achievement in quadrilaterals.

4.2.4 A Pairwise Comparison among Groups for Sub-Research Questions

A Pairwise comparison among groups was implemented to examine the research questions.

A pairwise comparison among groups was carried out to compare the effects of used materials (GeoGebra and concrete manipulative) on Quadrilateral Achievement Test posttest results and its result was shown in Table 10.

Table 10 A Pairwise Comparison

(I) group	(J) group	Mean Difference (I-J)	Sig.[b]
Control group that was provided just activity-based learning	Experimental group that was provided activity-based learning with using concrete manipulatives	-5.81	.32
	Experimental group that was provided activity-based learning by using GeoGebra	-16.23*	.00
Experimental group that was provided activity-based learning with using concrete manipulatives	Control group that was provided just activity-based learning	5.81	.32
	Experimental group that was provided activity-based learning by using GeoGebra	-10.42*	.02
Experimental group that was provided activity-based learning by using GeoGebra	Control group that was provided just activity-based learning	16.23*	.00
	Experimental group that was provided activity-based learning with using concrete manipulatives	10.42*	.02

As understood from the table, there was a statistically significant mean difference among the groups that were provided with activity based learning by using concrete manipulatives (*M*=56.25, *SD*=18.40), that were provided with activity based learning by using GeoGebra (*M*=65.13, *SD*=18.86) and that were provided only with activity-based learning (*M*=60.59, *SD*=23.30) in terms of posttest scores of Quadrilateral Achievement Test, F (2,56) = 86.60, p =.00, partial eta squared=.27. Partial eta squared showed a medium effect size (Cohen, 1988). To put it differently, 27 percent of the variance in posttest scores was explained by the effect of using GeoGebra in the treatment. This result indicates that the activity-based learning by using GeoGebra had a statistically significant effect on 5th-grade students' achievement in quadrilaterals.

4.5 Descriptive Analysis of Conceptual Questions on Defining Quadrilaterls

In addition to result of ANCOVA Q7, Q21a, Q23, and Q24 in Quadrilateral Achievement Test, which have more conceptual questions related to definition of quadrilaterals than the others, were examined to observe conceptual differences among the groups. These questions addressed the objectives in Table 3 such that students will be able to identify the properties of rectangle, square, parallelogram, rhombus and trapezoid, they will be able to construct the rectangle, square, parallelogram, rhombus and trapezoid on dot paper and they will be able to interpret the relationship among rectangle, square, parallelogram, rhombus and trapezoid. The percentages of correct answers of above-mentioned questions were represented in Table 11.

Table 11 The percentages of correct answers of Q7, Q21a, Q23, and Q24

	Experimental group that was implemented activity-based learning with using concrete manipulative	**Experimental group that was implemented activity-based learning by using GeoGebra**	**Control group that was implemented activity-based**
Questions	Percentage of correct answers	Percentage of correct answers	Percentage of correct answers
Q7	38.2	75.0	52.6
Q21a	41.4	65.0	58.4
Q23	52.4	80.0	57.9
Q24	68.2	85.0	41.6

Q7 was a multiple-choice question related to which sequence should be followed to get a square. 38.2 percent of students in one experimental group, which learned by using concrete manipulatives, gave the correct answer to Q7. 75.0 percent of students in the other experimental group, which learned by using GeoGebra, gave the correct answer to Q7. Moreover, 52.6 percent of students in control group gave the correct answer to Q7. Findings related to this question showed that many students in one experimental group that learned the topic by using GeoGebra succeeded in understanding specific rules that are required to be called a square. Approximately half of the students in a control group had an idea about which sequence should be followed to be a square while only 38 percent of students in the other experimental group, which learned the topic by using concrete manipulatives, had an idea about certain properties of a square.

When Q21a was analyzed, which was an open ended sub-question to examine whether student wrote the name of the given shapes correctly and to determine whether the diagonals of these shapes are equal lengths, 41.4 percent of students in the experimental group, which learned the topic by using concrete manipulatives, gave the correct answer to this question.

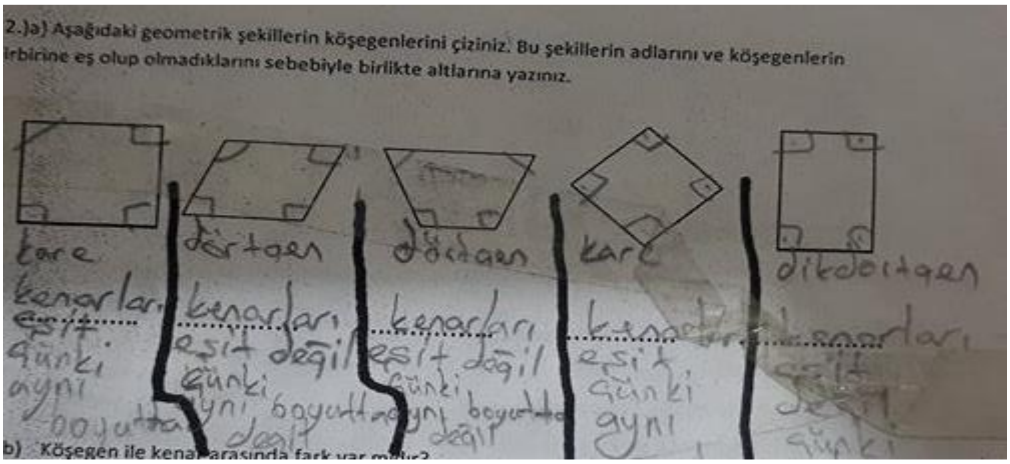

Figure 17 A student’s response or Q21a in concrete manipulative used group

65.0 percent of students in the other experimental group, which learned by using GeoGebra, gave the correct answer to the same question whereas 58.0 percent of students in control group gave the correct answer to the same question.

The result was similar to Q7 in terms of correct answers given by each group. There were some students' responses for Q21a in each group.

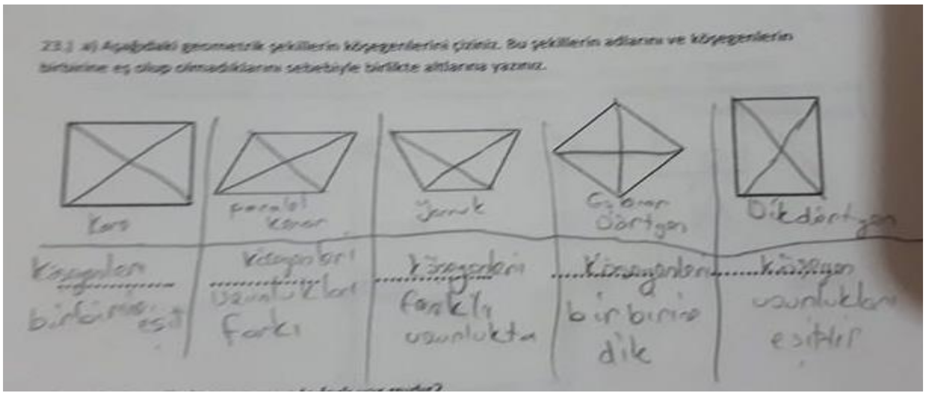

Figure 18 A student's response for Q21a in GeoGebra used group

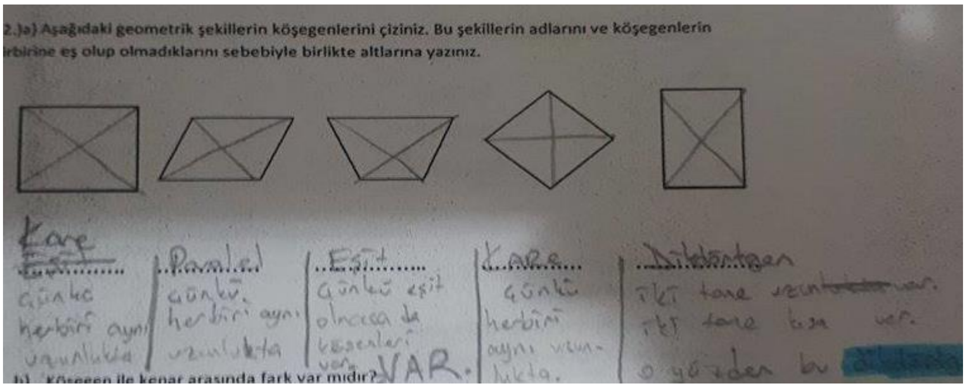

Figure 19 A student's response for Q21a in control group

Q23 was an open-ended question that was related to listing the conditions required to be called as quadrilaterals and drawing an example of any quadrilaterals. 52.4 percent of students in the experimental group, which learned the topic by using concrete manipulatives, gave the correct answer to Q23. It was observed that percentage of students who gave the correct answers increased in this question when compared to other questions.

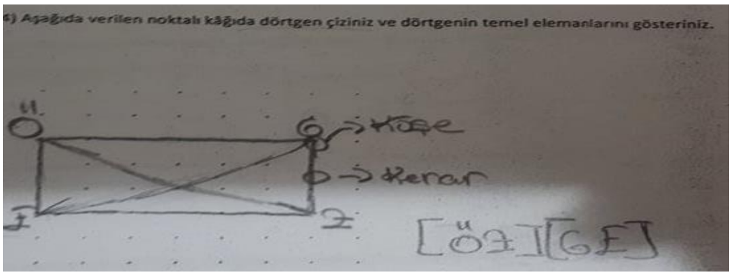

Figure 20 A student’s response for Q23 in concrete manipulative used group

57.9 percent of students in the control group gave the correct answer to Q23. These percentages indicated that many students- more than half of them were familiar with the properties of any quadrilaterals.

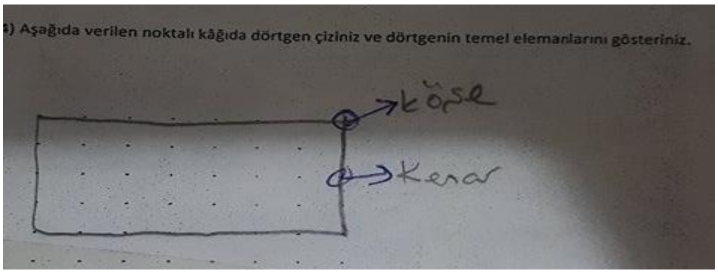

Figure 21 A student’s response for Q23 in control group

Moreover, the highest percentage was belonging to the experimental group that learned by using GeoGebra, namely 80.0 percent of students gave the correct answer to Q23.

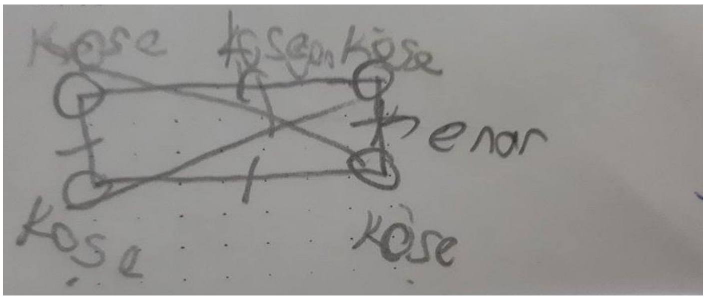

Figure 22 A student’s response for Q23 in GeoGebra used grou

Moreover, Q24 was an open-ended question that was related to identifying, drawing and comparing the properties of square and rectangle. 85.0 percent of students in the experimental group in which activity-based learning was implemented by using GeoGebra gave the correct answer to Q24.

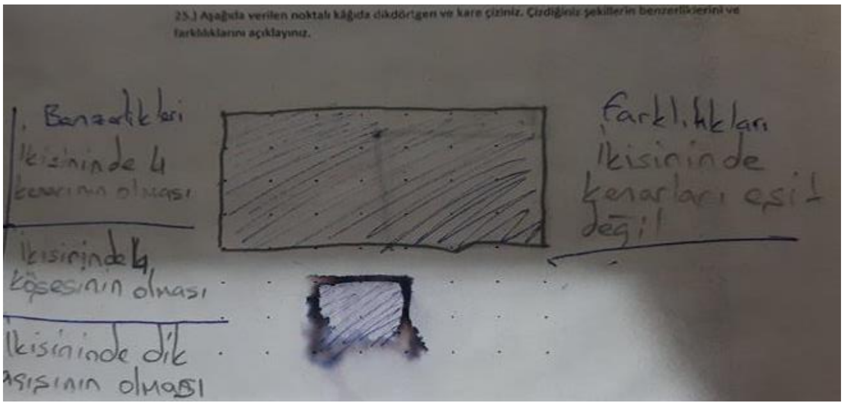

Figure 23 A student’s response for Q24 in GeoGebra used group

41.6 percent of students in control group gave the correct answer to Q24. There were sample answers of students in each group for Q24. There were some students’ responses for Q24 in each group.

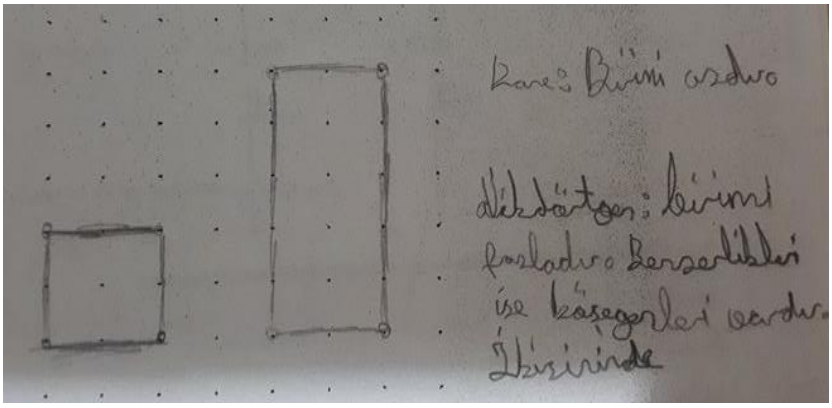

Figure 24 A student’s response for Q24 in control group

68.2 percent of students in the experimental group in which activity-based learning was implemented by using concrete manipulatives gave the correct answer to Q24.

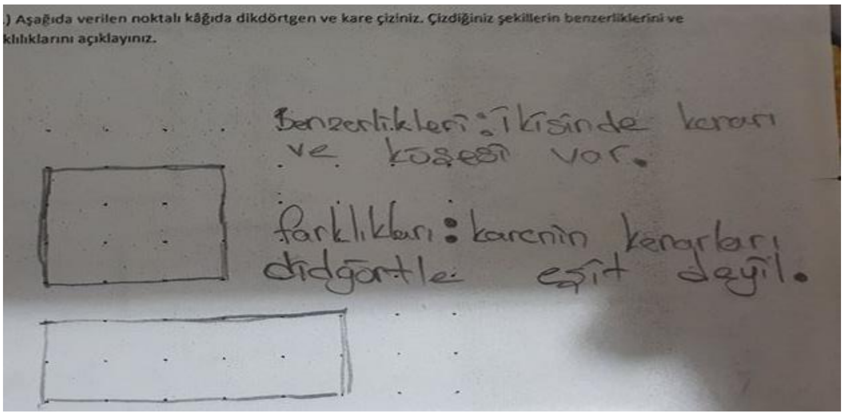

Figure 25 A student’s response for Q24 in concrete manipulative used group

To sum up, findings from these questions indicated that students that learned through GeoGebra had more competence in the properties of quadrilaterals than the students in the other experimental group and in the control group overall.

4.6 Analysis of Interviews

This part contains the existing students’ answers and explanations that were obtained from the interviews. Interviews were done with Merve that learned by using the GeoGebra in activity-based learning, Çiğdem that learned using concrete manipulatives in activity-based learning, and Berna that learned through an activity-based process. The semi-structured interviews focused on the main headings. Interviews began with the definition of any quadrilaterals. Below are some explanations from the interviews.

> Researcher: Can you define any of quadrilaterals? Which properties are required to be quadrilateral?
> Merve: A closed shape with four sides and four angles is a quadrilateral. Moreover, the sum of interior angles must be 360 degrees.

Çiğdem: When four sides, four interior angles and four sides and four diagonals exist, we can call it "quadrilateral". In addition, the sum of interior angles must be 360 degrees.
Berna: The sum of interior angles should be 360 degrees. There must be four sides, four vertices, four interior angles.

It can be concluded that all the participants mentioned a quadrilateral with four sides, four interior angles with sums equal to 360 degrees and four vertices. "A polygon with four-sides" is an economical definition of a quadrilateral that means mentioning only the sufficient and necessary information. The participants gave some extra information about defining the quadrilaterals. To illustrate, Merve, who differed from the other participants, mentioned an additional feature of "being a closed shape" to define it, and Çiğdem added her definition of having diagonals to be quadrilaterals. Furthermore, Merve and Çiğdem defined a quadrilateral while Berna listed all the properties of quadrilaterals, which were not a definition. All the participants had an idea about the nature of the definition, and they were expected to correctly define the mentioned quadrilaterals firstly. In addition, Çiğdem and Berna emphasized the same properties of quadrilaterals. The effect of the materials used (GeoGebra and concrete manipulatives) was not observed in this stage since all of them draw a rectangle as an example of any quadrilateral and listed almost the same properties of the quadrilateral. As a result, it can be concluded that the participants accepted square, rectangle, parallelogram, rhombus, and trapezoid as a quadrilateral. Interviews continued with the defining and drawing of square. There are some sections from these interviews based on defining and drawing the square

Researcher: I want you to draw any square and explain why we call it "square".
Merve: Since the distance between the points is equal to all lengths that mean all sides are equal lengths. On the other hand, being an equal length of all sides are not enough to be square. Moreover, all angles must be 90 degrees.
Çiğdem: There are four sides. Interior angles are 90 degrees. All sides are equal lengths and opposite sides are parallel.

Berna: All sides are equal. Opposite sides are parallel. Moreover, interior angles are 90 degrees.

As it can be understood from the speech, all participants had basic information about square and drew a prototypical square correctly on the paper. During the interviews, it was observed that the students did not have difficulty while drawing and defining the properties of the square. Çiğdem and Berna generally mentioned similar properties for the square, such as having four sides with equal lengths, angles with 90 degrees and being parallel to opposite sides. However, Merve emphasized different points from the others. To illustrate, she mentioned the distance between the units. Rather than considering the properties of a square as a whole, she considered each property one by one. She made inferences considering their experiences by GeoGebra and she displayed a more conceptual understanding than the others while connecting the properties of a square to each other. Moreover, she gave more detailed explanations than Çiğdem and Berna. Berna who should use the term "all sides with equal lengths" or "all sides with congruent sides" rather than "being all sides equal" defined the square poorly. Then, they started drawing and defining a rectangle. Below are some sections from these interviews based on defining and drawing a rectangle.

Researcher: I want you to draw any rectangle and explain why we call it "rectangle".
Merve: Since the the opposite sides have equal lengths whereas all sides are not equal. This makes rectangle different from a square. However, all angles are 90 degrees like a square. On the other hand, when I constructed a rectangle by using GeoGebra file and then made all sides of this rectangle with equal length. I got a square without changing anything except the length of sides. For this reason, we may say that square is a special form of a rectangle when all side of the rectangle are equal lengths, may not it?"
Çiğdem: The opposite sides have equal lengths. Like a square, all angles are 90 degrees. The opposite sides are parallel to each other.
Researcher: What do you think a square may be a special form of a rectangle?
Çiğdem: I don't think so.

Berna: There are four sides. On the other hand, opposite sides are parallel as well as having equal length. One of the sides must be longer than the other. All angles are 90 degrees.
Researcher: What do you think a square may be a special form of a rectangle?
Berna: No, since it must be a long side of a rectangle.

The data obtained showed that all participants were able to define the properties of a rectangle and drew it correctly. On the other hand, Berna had a common misconception about quadrilaterals such that it must have two short sides and two long sides. Çiğdem and Berna did not notice the hierarchal relationship between rectangle and square since the concept image in their mind did not match with accepting the square as a special type of rectangle. The reason for Çiğdem's explanations can be considered that she used concrete manipulatives during the learning process of quadrilaterals. She might focus on the color of geometry tiles while constructing rectangle since many of the students in that group used different color while assigning long and short side of rectangle. That is to say, if the students preferred red colored tile for long side, then they generally preferred blue colored tile that means each color has different lengths. In this treatment part of the study, even if some of the students discovered such a relationship and emphasized it during the class discussion, students generally forgot such a relation in this group.

On the other hand, Merve mentioned such inclusive relations between the square and rectangle by considering and connecting the properties of these quadrilaterals. Besides, she emphasized her experiences by GeoGebra throughout these explorations process since she made such sentences as "when I constructed a rectangle by using GeoGebra file and then made all sides of this rectangle in equal length, I got a square without changing anything except the length of sides. For this reason, we can say that square is a special form of a rectangle when all side of the rectangle are equal lengths, can't we?". For this reason, it can be concluded that using GeoGebra enables the participants to make inferences, connections among concepts more easily than by using other materials such as concrete manipulative in the learning process of quadrilaterals. Even if Çiğdem and Berna were encouraged to notice such a relationship by being asked a question by a researcher, they did not notice this relationship between a rectangle and a square. Then, they started drawing and defining the properties of parallelogram. Below are some example explanations from the participants.

> Researcher: I want you to draw any parallelogram and explain why we call it “parallelogram”.
> Merve: Since how long I extend these lines, it will never coincide at any point. For this “being parallel to lines” reason, we can call it parallelogram. Opposite angles are equal degrees. Moreover, I explored an interesting thing during exploration on GeoGebra. One angle may obtuse angle while one angle acute angle. The sequence of angle followed like this. Moreover, I explore common properties of these mentioned quadrilaterals such as “being parallel to opposite sides and being equal lengths of opposite sides.”
> Çiğdem: The opposite sides are parallel and equal length since we used the same color while constructing a parallelogram through geometry strips. On the other hand, we made the angles 90 degrees when we got a rectangle. This property may not be satisfied to get a parallelogram.
> Berna: (The students drew a rectangle different from the other students.) The opposite sides are parallel to each other. The name of parallelogram comes from here “being a parallel”. Let assume that these line segments are lines and I am extending these lines in this direction. They never coincide and this show is a parallel. For this reason, hıım, a square, and rectangle also are a parallelogram. Interior angles may be 90 degrees but it is not necessary. There may be obtuse and acute angles of a parallelogram.

As understood from such explanations, Merve and Berna especially emphazised the condition “being parallel” and they tried to explain how to receive parallel lines. For this reason, it can be concluded that Merve and Berna tried to make a connection between the name of parallelogram and the property that was related to being parallel of opposite sides.

All students listed common properties of the parallelogram correctly. The conditions of “all opposite side lengths’ being equal, being parallel and having all angles with 90 degrees” might be enough to define a parallelogram according to the participants. Merve and Çiğdem drew a prototypical parallelogram while Berna surprisingly drew a rectangle as an example of a parallelogram. When she was asked why she made such a drawing, she focused on the condition “being a parallel" that might help her to make a connection between parallelogram and other mentioned groups of quadrilaterals.

All participants were provided with the similarity between a rectangle and parallelogram in terms of appearance while finding relations among quadrilaterals. All students got a connection between parallelogram and rectangle. At this point, it can be concluded that the conditions "being equal lengths of opposite sides and being parallel of opposite sides played a crucial role to make such a connection. Here, the confusing point was considered as having angles with 90 degree to characterize a rectangle and having angles with any degree to be a parallelogram. Merve mentioned "One angle may obtuse angle while one angle acute angle. The sequence of angle followed like this" and found hierarchal relations among mentioned quadrilaterals without considering degrees of the angle and just focused on the other properties mentioned above. Unlike Çiğdem, Merve and Berna used the terms "acute angle" and "obtuse angle" as well as mentioning relationship among interior angles

> Researcher: Can you draw and explain the properties of rhombus?
> Merve: When the length of all sides of the parallelogram was equal length in GeoGebra file, we got a rhombus. For this reason, we can say that rhombus is a special form of parallelogram since some properties of parallelogram were conserved such as the degree of angle, just changed the length of sides. On the other hand, all sides are equal length. In this aspect, a rhombus is similar to a square. Can we say that a special form of both parallelogram and square for rhombus? Hımm. I am exciting. Each of quadrilaterals is relevant with each other.
> Çiğdem: Since opposite sides are equal lengths. Moreover, opposite sides are parallel. On the other hand, when all degrees are equal to 90 degrees, we can get a square. For this reason, interior angles should be different from 90 degrees.
> Berna: Since all sides are equal length. I benefit from the distance to prove this since all have 3 units. The length of all sides is 3 units we can say it rhombus.

The surprising point of these dialogs is that all students drew a square while defining a rhombus. The following pictures were taken during the interviews.

Figure 26 Drawings of students as an example of rhombus

The participants might prefer to draw square since they mainly focused on the condition "being an equal length of all sides" that would be enough to characterize rhombus according to their description. Merve and Çiğdem mentioned that the angles of a rhombus. On the other hand, just only Merve explored relations between rhombus and parallelogram and between rhombus and square, which excited her even if this situation was mentioned during the class activities and class discussion. That is to say, she expressed rhombus as a special form of both parallelogram and square. She made such a sentence as "when the length of all sides of the parallelogram was equal length, we got a rhombus. For this reason, we can say that rhombus is a special form of parallelogram.

In order to call a parallelogram a rhombus, some of its properties should be kept while some of them should be changed. For example, the property that opposite sides must be parallel should be kept while the property that all sides are equal length should be changed. In this aspect, a rhombus is similar to a square." She clarified which aspects are similar to each other. Besides, she generally grounded her explanations by the help of GeoGebra. However, Çiğdem mentioned that the angles of rhombus should be different from 90 degrees since when all sides are equal length and all angles with 90 degrees. Here, the conditions of "all angles with 90 degree", all sides being equal length" and "being parallel to opposite sides" might be characterized to the rhombus. On the other hand, Berna emphasized the properties of rhombus such that only all sides must be equal length. In this point, it can be concluded that Berna had a lack of defining of properties of the rhombus.

Then, they started drawing and defining a a trapezoid. Below are some dialogs from the interviews based on defining and drawing a trapezoid.

> Merve: Actually, two opposite sides are not parallel to each other while the other opposite sides should be parallel to each other.
> Researcher: Okay, what about the opposite sides those are not parallel to each other?
> Merve: Actually, there must be these opposite sides without parallel to each other. Otherwise, we cannot call it trapezoid.
> Çiğdem: We need a pair of "yamuk" opposite sides and one opposite sides should be parallel. Actually, two opposite sides are not parallel to each other while the other opposite sides should be parallel to each other.
> Berna: Actually, two opposite sides must be horizontal in other words being parallel. On the other hand, the other opposite sides are not necessary to be parallel.

As it was understood from the participants' explanations, there was a crucial problem related to the properties of a trapezoid due to the structural complexities of properties of trapezoid that may create such a problem. Based on their definition, a trapezoid is a quadrilateral with just one pair of parallel sides. If this property is satisfied, a trapezoid is formed automatically according to their explanations. They used the term "yamuk kenar" to indicate that the remaining sides are not parallel to each other rather than being curved.

Although Merve defined the properties of parallelogram, rectangle, square and rhombus correctly, it was observed that she had difficulty while defining the properties of a trapezoid. During the interviews, it was observed that the participants tried to find relations between the name of mentioned quadrilateral and its properties, and the name of quadrilaterals recalled the properties of quadrilaterals such as rhombus and parallelogram according to students' explanations. To illustrate, Çiğdem mentioned that "we call it parallelogram due to having parallel sides." Moreover, Berna mentioned only the condition "having equal lengths of sides" to be a rhombus. For this reason, even though it was emphasized the conditions to have a trapezoid, it was observed that the participants (Merve and Çiğdem) ignored some of these conditions and just focused on the name of trapezoid. Then, they constructed the properties of trapezoid based on its name, and they defined it as a quadrilateral with one pair of parallel sides. The term "yamuk kenar" used by Çiğdem supports such inferences.

In addition, Berna, which was different form the other participants, emphasized the term "being horizontal" and "being parallel." The reason might be conceded as the position of the drawn trapezoid in the plane. One of the opposite sides is drawn horizontally, which also automatically meets the condition "being parallel". The following picture was taken from the interview with Berna.

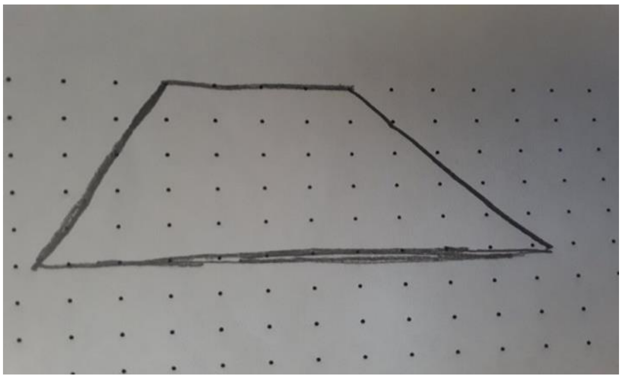

Figure 27 Berna's drawing for trapezoid

The surprising point is that only Berna made such a sentence that "The other opposite sides are not necessary to be parallel." Even though she defined a rhombus as a rectangle partially, she defined a parallelogram, square and trapezoid correctly. Moreover, she did not mention not being parallel to other pair of sides. On the other hand, all participants had some misconceptions about the definition of trapezoid. All of them drew similar trapezoid, prototypical trapezoid correctly.

4.7 Summary of the Result

The descriptive statistics was represented in Table 6. According to the pretest results of Quadrilateral Achievement Test (QAT), the experimental groups students' mean scores, who learned through activity-based using concrete manipulatives and through activity using GeoGebra, were 49.43 (*SD*=15.06) and 49.97 (*SD*=19.40) respectively. The students' pretest mean score on QAT in a control group was 46.52 (*SD*=18.34). On the basis of these pretest results, it can be said that the mean scores of students in experimental groups were approximately similar to each other although the mean scores of both experimental groups were relatively higher than that of the control group. According to the posttest results of Quadrilateral Achievement Test (QAT), the experimental groups students' mean scores, who learned through activity by using concrete manipulatives and through activity-based using GeoGebra, were 68.76 (*SD*=18.05) and 79.61 (*SD*=15.81) respectively. The mean score of the posttest for the control group was 60.64 (*SD*=19.62). For this reason, it can be said that the experimental group in which activity-based learning was implemented by using GeoGebra had the highest mean score among three classes in terms of posttest results.

In addition, the mean score of the experimental group in which activity-based learning was implemented by using concrete manipulative was higher than the mean of the control group in terms of posttest results. Similarly, based on the inferential statistics result, there was a statistically significant mean difference among the groups that were provided with activity-based learning by using concrete manipulatives (*M*=56.25, *SD*=18.40), the groups that were provided activity-based learning by using GeoGebra (*M*=65.13, *SD*=18.86) and the control group that was provided with only activity-based learning (*M*=60.59, *SD*=23.30) in terms of post-test scores of Quadrilateral Achievement Test, F (2,56)= 86.60, *p*=.00. That is to say, there was a significant difference in students' achievement between in an experimental group in which activity-based learning was implemented by using GeoGebra and an experimental group in which activity-based learning was implemented by using concrete manipulatives (*p* = 0.02), and between the experimental group in which activity-based learning was implemented by using GeoGebra and the control group that was provided with only activity-based learning (*p* =0.02), but no significant differences between the experimental group in which activity-based learning was implemented by using concrete manipulatives and the control group in which activity-based learning was implemented (*p* = 0.32). When Q7, Q21a, Q23, and Q24 were analyzed in Quadrilateral Achievement Test since they were more conceptual questions than the others in the test, the result supports the most positively affected group has been 5th-graders taught by GeoGebra on quadrilaterals. Moreover, qualitative results showed that the participant called Merve who learned by using GeoGebra displayed more conceptual understanding than the other participants since she listed the properties of mentioned quadrilateral based on her experiences by GeoGebra rather than memorizing the definition and the properties of quadrilaterals So the findings from the quantitative analysis were also confirmed by the findings in the interviews as well. She noticed the relations among the quadrilaterals and tried to explain to what extent mentioned quadrilaterals were similar to each other or differentiate from each other.

CHAPTER 5

DISCUSSION

This chapter involves a discussion of the results, the implications and recommendations for future studies. The study aimed at answering the following main research question:

- After controlling students' pre-test results, what is the effect of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals when compared to a control group in which only activity-based learning was implemented?

In addition, this study aimed to investigate the following questions:

- Is there a significant mean difference between the activity-based learning using concrete manipulative and activity-based learning only with respect to Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pretest result?
- Is there a significant mean difference between the activity-based learning using GeoGebra and activity-based learning only in quadrilaterals with respect to Quadrilaterals Achievement posttest result after controlling Quadrilateral Achievement Test pre-test result?
- How do the students' solutions and explanations change when they learn quadrilaterals by using different materials?

5.1 Discussion of the Findings from Geometry Achievement Test

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th-grade students' achievement in quadrilaterals compared to using activity-based learning only. The other purpose is to gain in depth understanding about the effects of used materials (GeoGebra and concrete manipulatives) on students' explanations on quadrilaterals through conducting interviews. An analysis of covariance (ANCOVA) was conducted to investigate the effect of activity-based learning by using GeoGebra and activity-based learning with using concrete manipulative on the achievement of 5^{th} grade students with respect to Quadrilateral Achievement Test (QAT) posttest results after controlling QAT pretest results.

The results of the statistical analyses showed that there was a statistically significant mean difference among the groups that were implemented activity-based learning using concrete manipulatives, and activity-based learning using GeoGebra and the control group that implemented activity-based learning in terms of posttest scores of QAT. This result indicates that the activity-based learning using GeoGebra had a statistically significant effect on the achievement of 5^{th} grade students in quadrilaterals, which is consistent with previous research studies in the literature (e.g., Diković, 2009; Doktoroğlu, 2013; Furkan, Zengin, & Kutluca, 2012; Furner & Marinas, 2006; Genç, 2010; Guven, 2012; Hannafin, Burruss, & Little, 2001; Hannafin, Truxaw, Vermillion & Liu, 2008; Healy & Hoyles, 2002; Isıksal & Askar, 2005; Pierce & Stacey, 2005; Reis & Ozdemir, 2010; Reimer & Moyer, 2005; Reisa, 2010; Shadaan & Leong, 2013; Roschelle, Pea, Hoadley, Gordin & Means, 2000; Zulnaidi & Zakaria, 2012; Yousef, 1997; Xing, Guo, Petakovic & Goggins, 2015).

There are some possible reasons that might explain the positive effects of the activity-based learning using GeoGebra on students' achievement in quadrilaterals. One of the reasons might be considered as the nature of the subject. Although all three groups in the present study had a chance to explore the properties of quadrilaterals by doing the same activity sheets, the nature of quadrilaterals might be in accordance with learning by GeoGebra more due to its dynamic structure. For example, a study on solving linear equations was conducted by Magruder (2012) in order to compare the effectiveness of using concrete and virtual manipulatives to learning methods without manipulatives. The mixed research design was preferred by applying pre and posttest to analyze data and 76 sixth grade students participated in the study. The analysis of quantitative data showed that there were statistically significant differences among posttest scores of groups in favor of the control group using learning methods without manipulatives. This result, which is not in line with the result of the current study, might be explained by the nature of the subjects since quadrilaterals could be more suitable for computer supported learning due to its visual structure than the topic "linear equation". Similarly, Jones (2010) stated that the students explored, constructed, conjectured and manipulated the figures more easily with the aid of GeoGebra than those who did not use GeoGebra. Sträßer (2001), Healy and Hoyles (2001) indicated that GeoGebra helps learners to have rich learning environments with the help of its dynamic features. This result was consistent with the results of Smith (2010), who characterized and compared the arguments of 8^{th} grade students while they were working on geometry in technological (using DGS) and non-technological environments (using traditional tools). The results of the study showed that the students who studied in technological environments developed more arguments and collected more additional data while doing the activities than those who studied in non-technological environments. For this reason, he suggested that teachers should pay more attention to design activities and lessons with the help of technological tools with dynamic features.

The second reason underlying the high achievement of students in quadrilaterals in GeoGebra classes might be considered as the amount of time. The students lost a certain amount of time due to an administrative point of collecting and disseminating the concrete manipulatives (Magruder, 2012). However, the students that learned the topic using GeoGebra saved time when compared to the students that learned using concrete manipulatives. Thanks to its dragging features, the students made many observations while constructing many types of certain quadrilaterals in a short time. It provided an advantage for the students to construct more quadrilaterals than using concrete manipulatives. Moreover, the dragging features allowed the students to resize and manipulate objects, observe the changes, test the hypotheses and make a generalization about certain shapes (Arzarello et al., 2002). Thus, the dragging options may account for the students' achievement in the activity-based learning group which used GeoGebra. Numerous studies were conducted to examine the effects of the dragging feature of dynamic geometry software that supported the result of the current study (Arzarello et al. 2002).

Although all the groups had the same learning environments and all the students studied on the same activity sheet, the students in each group used different materials which are GeoGebra, concrete manipulatives, traditional materials (rulers and protractors) during the lessons. The group that used traditional materials did not examine the properties of too many quadrilaterals during the activities since there were only five different sizes of certain quadrilaterals on the worksheets and it was expected from the students to make inferences and a generalization about studied quadrilaterals according to their observation with the given five different examples of studied quadrilaterals using traditional materials (rulers and protractors). The students that used the traditional materials did not get a chance to observe the changes on quadrilaterals; however, the students that used concrete manipulatives and GeoGebra had the opportunity to change certain features of studied quadrilaterals such as size, length and area, which provided the learners with rich learning environments. In addition, the students in experimental groups which used GeoGebra and concrete manipulatives had the chance to see and observe different views of objects easily in comparison to the control group students who used paper, pencil, ruler and protractor (Aarnes & Knudtzon, 2003). This kind of observation and explorations enable learners to comprehend the crucial properties of the studied shape (Akgül, 2014). The students who used traditional materials engaged in the static drawings whereas GeoGebra helped the students to construct certain quadrilaterals dynamically in a minute and geoboard and geometry tiles provided the students to construct certain properties of quadrilaterals by pulling the vertex of shapes in several minutes. In this way, the students in these groups made an observation by constructing different sizes and types of studied quadrilaterals and then made a generalization based on their observations. On the other hand, compared to the students that explored the topic using GeoGebra, the students who studied the same topic using concrete manipulatives worked on limited numbers of quadrilaterals.

The activity sheets, which were designed for the present study, maintained active involvement of the students; helping them to explore certain properties of quadrilaterals, make constructions and drawings on dot paper, make connections among their findings, list the common properties of studied quadrilaterals and share their findings first with a friend sitting next to her/him and then with the class by joining the class discussion. In this way, the students made inferences about the properties of quadrilaterals, after which, they were expected to generate a formal definition of certain quadrilaterals by themselves based on their observations and findings.

The students who used GeoGebra in their classes were the luckiest of the three groups because they were able to make more explorations and observations by using GeoGebra and this may account for such a result of this study. To put it differently, the experimental group, which used GeoGebra, had the opportunity to observe and construct more quadrilaterals than the other groups. This helped them understand the quadrilaterals better and participate in the discussions more. Similarly, findings from the analysis of conceptual questions supported the result that students who learned through GeoGebra had more competence in the properties of quadrilaterals than the students in the other experimental group and in the control group overall.

Moreover, the structure of the materials used in the lectures except for GeoGebra might be responsible for the fact that there are no differences in the means of the groups which used concrete manipulatives (geoboard and geometry tiles) and traditional materials (ruler and protractor) in terms of posttest results. It is because concrete manipulatives and traditional materials have similar structures and they are all physical objects used in mathematic lessons and they are touchable mathematical tools.

Another reason underlying the students' highest achievement in quadrilaterals in GeoGebra classes might be the use of the computer, which might enable mathematics lectures to be more exciting and more interesting for students with the help of using dynamic software. During the treatment, it was observed that the students who used GeoGebra attended the lectures more eagerly when compared to the other students who participated in the study. As mentioned previously, many of the students at the school had low socioeconomic status and did not own a computer at home and it was observed that they enjoyed the activities and were quite excited while spending time on computer and making observations with the aid of GeoGebra. Furthermore, Furner and Marinas (2006) and Choate (1992) emphasized that the students were more willing to learn activities in a dynamic learning environment. Similarly, technological developments may attract students' interest more than concrete manipulatives or traditional materials (Bates & Poole, 2003).

5.2 Discussion of the Findings from the Interviews

The students made connections among findings and defined the quadrilaterals with their own words rather than just memorizing the properties and formulas of quadrilaterals and these were examined by the interviews as well as QAT. To illustrate, Merve, who used GeoGebra, seemed to be more aware of the relations among quadrilaterals than the other participants. When they were asked to explain the common properties of quadrilaterals, Merve was the only student who was able to identify a rhombus as special form of parallelogram and square. Moreover, she could list the properties of the mentioned quadrilaterals by using her words rather than memorizing the formal definition of it and she grounded her explanations on experiences with GeoGebra. For example, Merve was asked to list the properties of rhombus and she uttered such sentences as “When the length of all sides of a parallelogram has equal length in a GeoGebra file, we got a rhombus. For this reason, we can say that rhombus is a special form of parallelogram since some properties of a parallelogram such as the degree of angles are conserved and the length of the sides change. On the other hand, all sides have equal length. In this aspect, a rhombus is similar to a square. Can we say that rhombus is a special form of both parallelogram and square? Hımm. I am excited. Each quadrilateral is relevant to each other.”

As it can be understood from Merve’s explanations, she noticed the relationships between a parallelogram and a rhombus and between a square and a rhombus with the help of GeoGebra. She reached level 3 according to Van Hiele Geometric Thinking Levels as she comprehended the properties of quadrilaterals in general and made a comparison among them to notice the differences and similarities between the mentioned quadrilaterals. She changed certain properties of parallelogram such as the length of sides with the aid of GeoGebra and got a rhombus. For example, she mentioned that some properties of a parallelogram might be conserved to be a rhombus such as the degree of angles and some properties of parallelogram must be changed to be rhombus such as the length of sides. At this point, she likened rhombus to a square in terms of having equal length of sides. This indicated that she was aware of the inclusive relations between quadrilaterals to some extent. Nevertheless, it was observed that she noticed the relations among them on a limited scale. To illustrate, she listed the properties of a trapezoid as “There must be these opposite sides without being parallel to each other. Otherwise, we cannot call it a trapezoid.” As it is understood, she did not define a trapezoid correctly. Nor did she notice the relationship between the mentioned quadrilaterals and a trapezoid.

When the same question was asked to Çiğdem, who used concrete manipulatives and Berna, who used traditional materials, they could not adequately define and list the properties of rhombus. Çiğdem stated the following sentence: “The opposite sides have equal lengths. Moreover, the opposite sides are parallel.

On the other hand, when all degrees are equal to 90 degrees, we can get a square. For this reason, interior angles should be different from 90 degrees." As it can be understood from Çiğdem's explanations, although she listed the properties of rhombus, she did not notice the relationship between a rhombus and a square. Çiğdem mentioned "We need a pair of "yamuk" (uneven) opposite sides and the opposite sides should be parallel. Actually, two opposite sides are not parallel to each other while the other opposite sides should be parallel to each other." She found a relationship between the name of the mentioned quadrilateral and its properties since she emphasized to have "yamuk sides". Moreover, based on her definition; a trapezoid is a quadrilateral with just one pair of parallel sides. Furthermore, Berna listed the properties of a rhombus as "since all sides have equal length, I benefit from the distance to prove this since they all have 3 units. If the length of all sides is 3 units, we can say it is a rhombus."

Considering Berna's explanations, she only focused on the condition of rhombus "all sides with equal lengths". A surprising point was observed while Berna was defining the properties of trapezoid since it was observed that she had difficulty in defining other quadrilaterals to some extent while just Berna made such a sentence as "One pair of opposite sides must be parallel and the other opposite sides are not necessary to be parallel." Different from the other participants, Berna was aware of the fact that there needs to be at least one pair of parallel sides to characterize a trapezoid. The reason behind such a definition might be considered as static drawings and static observations. Rather than measuring the length of sides and constructing opposite sides with one click, Berna spent effort using a ruler and a protractor to do so which might affect her definition of a 'trapezoid'.

Another surprising point was that although the participants studied on quadrilaterals by using different materials (GeoGebra, concrete manipulatives and rulers and protractors) throughout the treatments, all of which considered only the prototypical images and drew similar shapes during the interviews. On the other hand, it was observed that Merve used more creative sentences and emphasized more different points of the mentioned quadrilaterals than the other participants with making connections among quadrilaterals. Marger (2012) stated that making connections is a key to learn mathematics effectively and build meaningful knowledge. In this point, visualization might play a crucial role in students' explanations since it is a process and product of some communications of concepts and interpretations of them in children's minds (Arcavi, 2003). Moreover, using GeoGebra might enhance visualization skills of students and it might enable them to construct more conceptual understanding with rich visual environments since it provides an opportunity for students to observe minimal changes on studied quadrilaterals dynamically in terms of different perspectives. Similarly, many studies in the literature have supported such a result that dynamic learning environment enables learners to visualize the mathematical ideas and concepts, which help students to construct conceptual understanding in geometry education (Battista, 1994; Gutiérrez, 1996; Hacıömeroğlu, 2011; Harnisch, 2000; Yılmaz, Argün & Keskin, 2009). Similarly, Hohenwarter et al. (2008) stated that GeoGebra enables students to understand concepts more specifically through visualization. Merve mentioned her experiences by GeoGebra and these experiences helped her remember what she did during the treatment.

It was noticed that there were some conceptual differences among students' explanations while defining quadrilaterals. Based on the student's responses and explanations, it could be concluded that thanks to observing changes on quadrilaterals, the students took an advantage to explore the properties of quadrilateral supported with the rich learning environment. Yılmaz, Argün and Keskin (2009) mentioned that visualization had a crucial place when noticing certain rules and relations. For this reason, GeoGebra played an important role in students' learning process as it encourages learners to use visualization skills (Samur, 2015). Similarly, Furner and Escuder (2010) claimed that students got a chance to be able to make connections between mathematics concepts and images with the aid of GeoGebra. Findings from Merve's responses expressed that exploring and observing with GeoGebra affected her learning process positively.

Considering the responses of all three interviewees, it can be said that Merve achieved a more meaningful learning than the other participants. Souter (2001) mentioned that technology use in mathematics has increased students' achievement and enhanced their perception.

5.3 Discussion of the Findings from Geometry Achievement Test and Interviews

Quantitative data analysis techniques were utilized to analyze pre and posttest data of 5^{th} grade students (n=60). ANCOVA showed that there were statistically significant differences based on students' posttest results in favor of the experimental group which implemented activity-based learning by GeoGebra. The descriptive analysis of the posttest scores was consistent with the result analyzed by ANCOVA. The group which applied activity based learning by GeoGebra had the highest scores based on posttest of QAT. Findings from qualitative data showed that Merve constructed more meaningful knowledge. Rather than listing the properties of asked quadrilaterals, she defined it with her own words, and made inferences from her observation with GeoGebra. She tried to find relations among quadrilaterals by noticing similar features and classified them based on these features. Although both quantitative and qualitative data analysis indicated that using GeoGebra in activity-based learning while teaching quadrilaterals had a positive effect on the students' achievement and enhanced students' perception, the students in all three groups were actively engaged in the lessons.

5.4 Implications

The results of several studies showed that using dynamic geometry software such as GeoGebra, Cabri 3D and Geometer's Sketchpad increased and improved the students' achievement in mathematics (e.g. Furkan, Zengin, & Kutluca, 2012; Furner & Marinas, 2006; Healy & Hoyles, 2002; Isıksal & Askar, 2005; Petakovic

& Goggins, 2015; Pierce & Stacey, 2005; Roschelle, Pea, Hoadley, Gordin, & Means, 2000; Shadaan & Leong, 2013). Mathematics teachers, curriculum developers, teacher educators and educational policy makers should be cognizant of integrating technology into mathematics education. Curriculum developers should give more importance to design technology based instructions. Teachers should be able to integrate technology into their lessons when they graduate from university. For this reason, teacher educators should make sure that pre-service teachers gain technological literacy. For example, it might be expected from them to prepare lesson plans utilizing technological tools. Moreover, educational policy makers should raise awareness among teachers on the importance of using technology in mathematics educations especially geometry education since many teachers do not support their lessons with technology.

There are some reasons for this, the first of which is that some studies indicated fears of teachers while using technology in their lessons as an instructional tool (e.g. Schmidt & Callahan, 1992; Guerrero, Walker, & Dugdale, 2004). Teachers no equipped with sufficient knowledge on the usage of educational technology might avoid designing their lessons by using them. In other words, teachers generally do not have an idea about how to use technological instruments and integrate them into their lessons. In order to solve this, a seminar can be conducted and at the beginning of it, smart boards can be used and the seminar can continue with special mathematical and geometrical softwares such as GeoGebra, Cabri 3D, and Geometer' Sketchpad. In addition, it was observed by the researcher that many teachers do not have an idea about how concrete manipulatives should be used in their lessons plans.

Similar behavior was observed during integrating concrete manipulatives into their lessons. Although many teachers believe that using concrete manipulatives enhances students' learning, only 19% percent of in-service teachers would like to make use of the manipulatives in the classroom (Howard et al., 1997; Marshall & Swan, 2008;). Furthermore, in service and pre-service mathematics teachers should know different teaching and learning methods in mathematics education. They should be careful when designing their lessons and they should be student-centered and use both technology and concrete manipulative enriched methods of instructions. Considering all the advantages of using dynamic geometry software, it is suggested to use such software and concrete manipulatives through a longer time span for teaching different subjects to provide better comprehension in students' achievement. For these reasons, in traditional geometry education; activities, activity sheets and textbooks should be revised and be enriched with the integration of GeoGebra and concrete manipulatives.

The important point of using concrete manipulatives during the lessons is to explain to students the intended use of the manipulatives well. If the meaning of concrete manipulatives had not been emphasized in the present study, students might have used them in their learning process like toys. In addition, the hygiene issue should be considered since manipulatives sometimes fell down and got dirty. Then, the students touched these and some of them put some pieces in their mouth. Therefore, manipulatives should be kept in a hygienic place and should be cleaned at times. One further implication can be recommended for the curriculum developers. The name of trapezoid is translated into Turkish language as "yamuk" (uneven or crooked). The name of trapezoid as "yamuk" should be changed since many students found a relationship between the name of trapezoid and its properties. Many students assumed to have one pair of "yamuk kenar" (uneven sides), which means not to be parallel in opposite sides, to characterize a trapezoid. Mathematics curriculum for elementary students might be redesigned considering this issue by curriculum developers.

5.5 Recommendations for the Further Research Studies

The aim of this study is to examine the effects of activity-based learning using concrete manipulatives and activity-based learning using GeoGebra on 5th grade students' achievement in quadrilaterals compared to using activity-based learning only. The other purpose is to gain in depth understanding about the effects of used materials (GeoGebra and concrete manipulatives) on students' explanations on quadrilaterals through conducting interviews. This study concentrated on a quadrilateral topic on a 5th grade mathematics lesson in one of the public schools in the city of Düzce, Turkey in the light of the objectives by the National Mathematics Curriculum of Turkey. For this reason, the results of this study cannot be generalized for all students in 5th grade as well as the other grade levels and other content areas of mathematics. Moreover, further researches should be carried out with other 5th graders in Düzce and in other cities in Turkey. Moreover, similar learning environments and similar materials should be used while teaching different topics of mathematics to evaluate the effects of materials on those topics.

In addition, this study is restricted to quadrilaterals and time span of four weeks and included the treatment and application of pre-and posttest of QAT. For this reason, further researches should be conducted to investigate the long-term effects of using concrete manipulatives and GeoGebra on the achievement of students in different learning areas. In addition, further research should be implemented to investigate the effect of using GeoGebra and concrete manipulatives at the same time. The treatment's effects might be enhanced by implementing long-term research at the same grade level with different learning areas.The researcher, as the teacher of the students, taught them how to use concrete manipulatives, GeoGebra, and protractor during previous semesters while teaching different topics before the treatments began. For this reason, extra time was not spent to teach the use of them. Moreover, activity-based learning was applied while focusing on different subjects such as decimal numbers and fractions. Hence, the students were familiar with both activity-based learning in terms of the procedures to be followed, and the mathematical materials to be used such as GeoGebra, geometry tiles, geoboard, and protractor. It is recommended for further studies to integrate this equipment with different subjects before the treatment begins. The participants of this study had a low socio-economic level. Many students gained technological literacy by the help of a teacher during the semester.

For this reason, schools especially such located in rural areas should be given extra time when students spend time on computer. To illustrate, computer labs should be kept open during the lunch break and a time schedule can be prepared for each class. In this way, students will know at which time interval they can spend time in the computer laboratory. Schools should manage the web pages students can visit and give access to only educational pages. Similarly, a class can be provided for using concrete manipulatives and it might be expected from students to design mathematical games and activities using these manipulatives. In addition, further studies could increase the number of subjects. In the present study, there were sixty students only. Convenience sampling was chosen for quantitative data and purposive sample selection was used for qualitative data collection. Random sampling methods might be selected to collect both quantitative and qualitative data in the further studies to get a chance to enhance the generalizability of their studies with a broader population that have similar characteristics.

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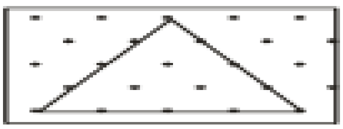
APPENDICES

APPENDIX A

DÖRTGENLER BAŞARI TESTİ

Sevgili Öğrenciler ☺ Bu test "Dörtgenler Konusu" ile ilgili 25 sorudan oluşmaktadır. Bazı sorular bir ya da birkaç alt soru içermektedir. Bazılarında ise açıklama yapmanız istenmektedir. **Lütfen tüm soruları cevaplamaya çalışınız. Süre 2 (iki) ders saatidir. Her soru 4 puandır**

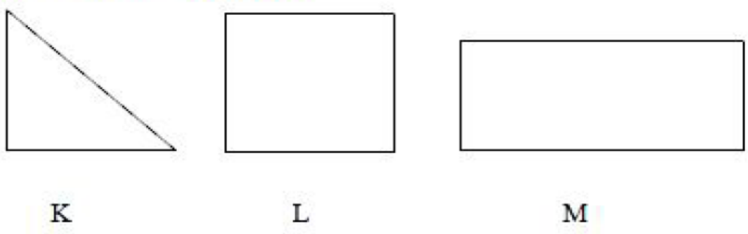
1. Şekilde iki nokta arası 3 cm ise üçgenin çevresi kaç cm'dir?



A)24

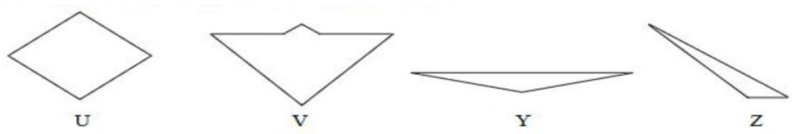
B)36 C)42 D)48

2. Aşağıdakilerden hangisi ya da hangileri karedir?



A) Yalnız K
B) Yalnız L
C) L ve M
D) Hepsi karedir.

3. Aşağıdakilerden hangisi ya da hangileri üçgendir?



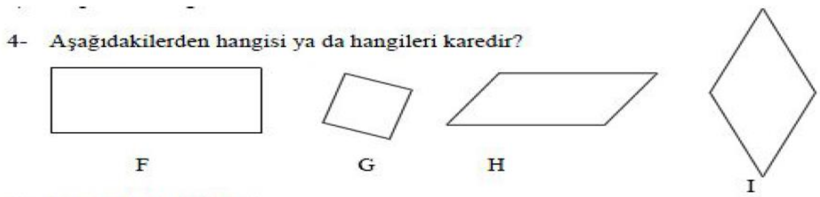
A) Hiçbiri üçgen değildir.

B) Yalnız V

C) Yalnız Y

D) Y ve Z

4. Aşağıdakilerden hangisi ya da hangileri karedir?



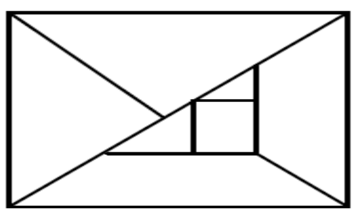
A) Yalnız G

B) F ve G

C) G ve I

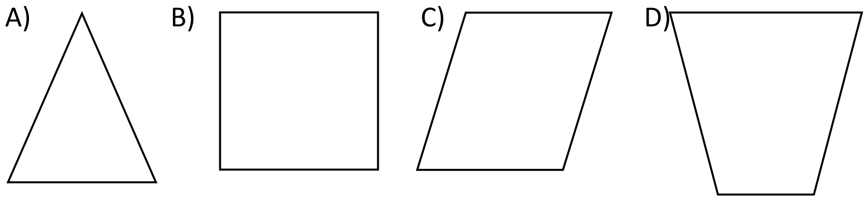
D)Hiçbiri kare değildir.

5. Aşağıdaki şekil boyanacaktır. Boyama yapılırken şekil olarak birbirine benzer olan kısımlar aynı renkte boyanacaktır. Buna göre aşağıdaki şekil boyanırken en az kaç renk kullanılmalıdır?

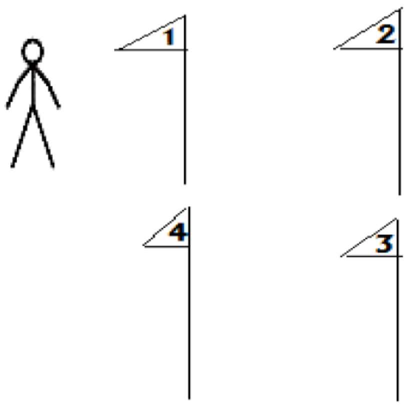


A)2 B)3 C)4 D)5

6. Aşağıdaki şekillerden hangisinin köşegeni yoktur?



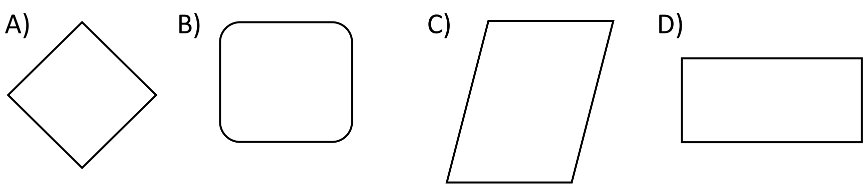
7. Bir oyun alanına yerleştirilmiş 4 bayrak bulunmaktadır. Bu bayraklar gezilerek bir kare oluşturulmaktadır. Buna göre şekildeki çocuk bayrakları hangi sırayla gezerse bir kare oluşturabilir?



A)1,2,4,3,1 B)1,4,3,2,1 C)1,2,3,1,4

D)1,4,3,1,2

8. Aşağıdaki dörtgenlerden hangisi bir karedir?



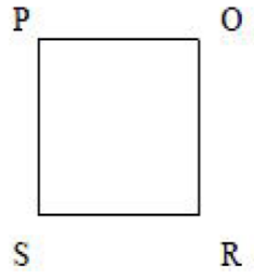
9. PORS bir karedir. Aşağıdakilerden hangi özzellik her kare için doğrudur?

A) [PR] ve [RS] eşit uzunluktadır.

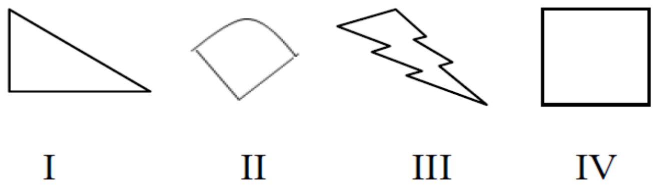
B) [OS] ve [PR] diktir.

C) [PS] ve [OR] diktir.

D) [PS] ve [OS] eşit uzuluktadır.

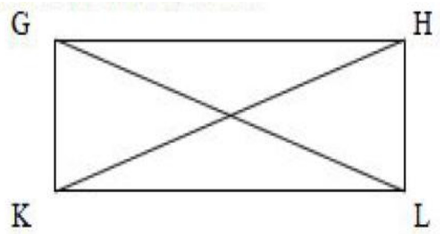


10. Aşağıdaki şekillerden çokgen olmayanları hangi seçenekte doğru olarak sıralanmıştır?



A)Yalnız II   B) II ve IV   C) II ve IV   D) II ve III

11. Bir GHJK dikdörtgeninde, [GL] ve [HK] köşegendir. Buna göre aşağıdakilerden hangisi her dikdörtgen için doğrudur?



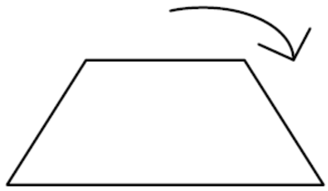
A) 4 dik açısı vardır.

B)Köşegenlerinin uzunlukları eşittir.

C) Karşılıklı kenarlarının uzunlukları eşittir.

D) Seçeneklerin hepsi her dikdörtgen için doğrudur.

12. Aşağıda verilen yamuk ok yönünde baş aşağı döndürüldüğünde, aşağıdaki özelliklerinden hangisi değişmez?



I. İç açısı ölçüsü toplamı

II. Çevresi

III. Köşegenlerinin sayısı

a) I b) I ve II c) II ve III d) I ,II, III

13. Aşağıda verilen bilgilerden hangisi daima doğrudur?

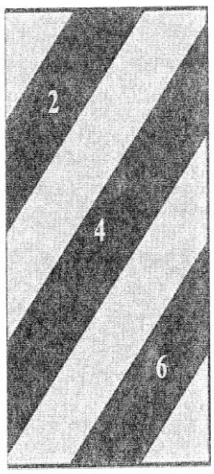
A)Uçurtma paralelkenar şeklinde olmalıdır.

B)Yamuk bir dörtgendir.

C) Paralelkenar bir dikdörtgendir.

D) Eşkenar dörtgen bir karedir.

14. Aşağıda trafik işaretine (dönüş adası ek levhası) göre verilen ifadelere doğru ya da yanlış seçeneği işaretleyiniz.



	Doğru	Yanlış
1 ve 7 numaralı bölgeler üçgendir.		
2 ve 6 numaralı bölgeler paralelkenardır.		
4 numaralı bölge paralelkenardır.		
3 ve 4 numaralı bölgelerin birleşimi beşgendir.		

15.Aşağıda seçeneklerde eşkenar dörtgenin özellikleri sıralanmıştır. Sıralanan özelliklerden hangisi eşkenar dörtgene ait değildir?

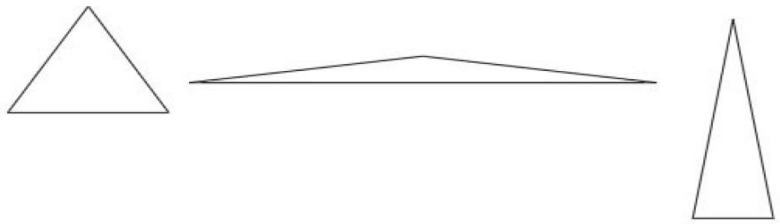
A) Karşılıklı açıları eşittirç

B) Bütün kenar uzunluklar eşittir.

C)Köşegen
uzunlukları
eşit değildir.

D)Bütün açıları birbirine eşittir.

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



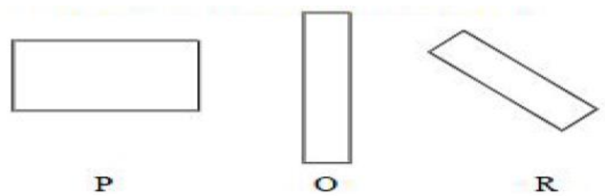
A) Üç kenarı eşit uzulukta olmalıdır.

B) Bir kenarının uzunluğu, diğerinin iki katı olmalıdır.

C) Ölçüsü eşit olan en az iki açısı olmalıdır.

D) Üç açısının da ölçüsü eşit olmalıdır.

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



A) Yalnız O B) Yalnız R C) P ve O D) Hepsi

18. Aşağıda herhangi bir paralelkenar ile ilgili bilgiler verilmiştir. Bu bilgilerden hangisi yalnıştır?

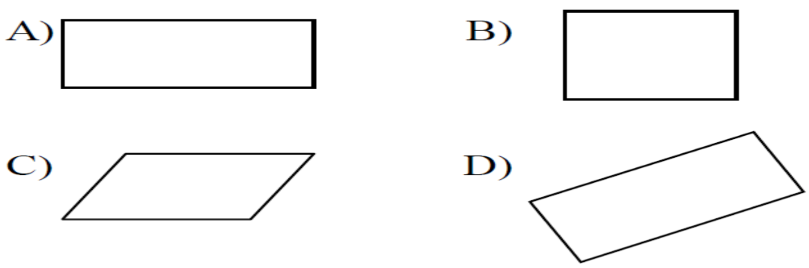
A) Karşılıklı açıları birbirine eşittir.

B)Köşegen uzunlukları birbirine eşittir.

C) Karşılıklı kenar uzunlukları birbirine eşittir.

D) İç açıları toplamı 360^0 dir.

19. Ahmet ‘e göre bir şeklin dikdörtgen olabilmesi için sadece dört kenarının olması yeterlidir. Buna göre aşağıdaki şekillerden hangisi Ahmet’in dikdörtgen tanımının eksik olduğunu ortaya koymaktadır?



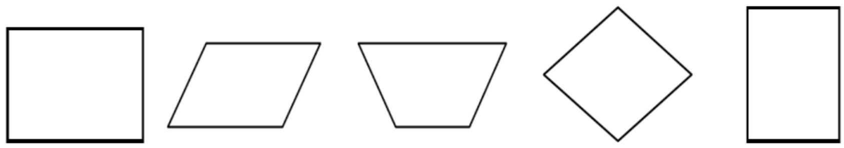
20. Aşağıda bazı dörtgenler ve bunlara ait kenar özellikleri verilmiştir.

1. Kare	a) Üç kenarı vardır.
2. Üçgen	b) Dört kenar uzunluğu birbirine eşittir.
3.Paralelkenar	c) Karşılıklı kenarları birbirine paraleldir.
4. Dikdörtgen	d) Karşılıklı kenar uzunlukları farklıdır.

Buna göre aşağıdaki eşleştirmelerden hangisi yanlıştır?

A) 1-b B) 3-d C)2-a D)4-c

21.



……………… ……………… ……………… ……………… ………………

a) Aşağıdaki geometrik şekillerin köşegenlerini çiziniz. Bu şekillerin adlarını ve köşegenlerin birbirine eş olup olmadıklarını sebebiyle birlikte altlarına yazınız. (2 p)

b) Köşegen ile kenar arasında fark var mıdır? (2p)

22. Aşağıda verilen noktalı kâğıda paralel iki doğru çiziniz. İki doğrunun paralel olduğunu nasıl açıklarsınız?

23.Aşağıda verilen noktalı kâğıda dörtgen çiziniz ve dörtgenin temel elemanlarını gösteriniz.

24. Aşağıda verilen noktalı kâğıda dikdörtgen ve kare çiziniz. Çizdiğiniz şekillerin benzerliklerini ve farklılıklarını açıklayınız.

25. Kare, dikdörtgen, eşkenar dörtgen, yamuk, paralelkenar şekillerini kullarak bir oyun parkı modeli çiziniz.

APPENDIX B

OPEN-ENDED QUESTIONS' SCORING RUBRIC OF QUADRİLATERAL ACHIEVEMENT TEST

Scores	Answer Types
0	No answer. Completely irrelevant or wrong answer.
1	Misconception of the inquiry and the right answer through that misconception without clarification.
2	Halfway understanding without clarification. Minimal comprehension of the task.
3	Correct answer without clarification. Mistake sourced drawing Correct rule application but wrong result Limited success resulting in an inconsistent or flawed explanation Correct drawing without explanation
4	Lacking in some minor ways of answer or explanation Correct answer with sufficient explanation A response displaying full and complete understanding

APPENDIX C

LESSON PLANS FOR GEOGEBRA USED CLASS

Purpose:

These lessons are designed to introduce students to general properties of quadrilaterals. Included in this lesson are discussions of properties of quadrilaterals such as parallelograms, rectangles, square, rhombus and trapezoids.

During:

14 lesson hours

Objectives:

After this lesson, students should be able to

- be familiar with properties of quadrilaterals.
- construct particular quadrilaterals based on specific characteristics of the quadrilaterals.

Student Prerequisites:

- *Geometric:* Students must be able to:
  - recognize the general shape of a square and a rectangle.
  - recall information about angles (particularly right angles), parallel lines, and possibly the concept of congruency.
- *Technological:* Students must be able to:
  - perform basic mouse manipulations such as point, click and drag.
  - have an information about Geogebra Usage.

Key Terms:

This lesson introduces students to the following terms through the included discussions:

Quadrilateral, congruent, parallel, right angle, acute angle, obtuse angle, rectangle, square, parallelogram, rhombus, trapezoid.

Part 1:

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of quadrilaterals.

Beginning (10 min)

It is reminded students to what they learned in previous lessons that will be related to this lesson and/or have them begin to think about the words and ideas of future lessons such that

It can be repeated general properties of triangle and it is emphasized triangle is a kind of polygon. Then, it is mentioned that what they will be doing and learning today such that "Today, class, we will be talking more about the four-sided figures, called quadrilaterals. What do you know about quadrilaterals? Can you give an example about quadrilaterals in your daily life?"

It is expressed student' expectation from students' during the lessons.

During (50 min)

It is expected from students to move on Çalışma Yaprağı 1.

Çalışma Yaprağı 1

Dörtgenler 1 adlı GeoGebra dosyasını açınız. Dosyada herhangi bir dörtgen bulunmaktadır.Dörtgeni köşe noktalarından çekerek veya yandaki sürgülerle kenar uzunluklarını değiştirerek en az 5 yeni dörtgen oluşturarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Oluşturduğunuz dörtgenlerin kenarlarının birbiriyle durumu hakkında ne söylenebilirsiniz? Sizce oluşturduklarınızın dışında hangi durumlar olabilir? Açıklayınız.

2) Oluşurtuğunuz dörtgenlerin kenar uzunlukları arasında bir ilişki var mıdır? Herhangi bir ilişki olabilir mi sizce? Açıklayınız.

3) Oluşturduğunuz dörtgelerin açı ölçüleri arasında bir ilişki var mıdır? Herhangi bir ilişki olabilir mi sizce? Açıklayınız.

During the activiy, teacher observes what students did and their behaviour. It is expected from students to notice the properties of each constructed quadrilaterals (measure of the length of sides and diagonals and measure of and angles of each quadrilateral) and to draw these shapes on their paper (In this way; it is aimed to construct quadrilaterals with different angles and lengths and be familiar with different quadrilaterals).

Closure (20 min)

It is allowed students to work with a firewnd sitting next to them to share what they found. Then, it is expected them to summarize in each group what we learned this lesson such that he or she explains that the quadrilateral on the screen will always remain as a quadrilateral, even though you move the sides and corners. Then, teacher summarizes the activity

Part 2

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of parallelograms.

Beginning (20 min)

Remind students of what they learned in previous lessons. It can be remembered general properties of quadrilaterals to students and then it is said that "Today we are going to talk about special kind of quadrilaterals called parallelogram."

During (50 min)

It is wanted from students to open GeoGebra file called "Dörtgenler 2".Then, it is excpected students to follow regulations on activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 2

a) Bilgisayarınızda "**Dörgenler 2"** isimli GeoGebra dosyasını açınız.

b) Yandaki sürgüyü kullanarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Yapmış olduğunuz gözlemler sonucunda sizce paralelkenar bir dörtgen midir? Açıklayınız.

2) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

3) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız.

4) Yapmış olduğunuz gözlemler sonucunda paralelkenarın açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

5) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin paralelkenar olabilmesi için hangi şartları sağlaması gerekir?

6) Yapmış olduğunuz gözlemler sonucunda paralelkenarı herhangi bir dörtgendenn ayıran özellik veya özellikler nelerdir? Açıklayınız.

7) Paralelkenraın genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

8) Yeni bir Geogebra dosyası açınız ve paralelkenarı genel özelliklerini düşünerek bir paralelkenar çiziniz ve adınız soyadnız dosya adı olacak şekilde masa üstüne kaydediniz.

During the lessons, teacher observes what they did and takes note about their behavior.

Closure (20 min)
The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of parallelogram and students note these as properties of parallelogram on their note book. It is wanted from students to given example about parallelogram which they saw in their daily life.

Part 3
During: 2 Lesson Hours
Objective: Students should be able to recognize general properties of rectangle

Beginning (10 min)

Remind students of what they learned in previous lessons. It can be remembered general properties of parallelogram to students and then it is said that “Today, again we are going to talk about special kind of quadrilaterals called rectangle.”

During (50 min)

It is expected from students to open GeoGebra file called “Dörtgenler 2”.Then, it is wanted from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 3

a) Bilgisayarınızda **Dörgenler 2** isimli GeoGebra dosyasını açınız.
b Yandaki sürgüyü kullanarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Yapmış olduğunuz gözlemler sonucunda sizce dikdörtgen bir dörtgen midir? Açıklayınız.

2) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

3) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız

4) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

5) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin dikdörtgen olabilmesi için hangi şartları sağlaması gerekir?

6) Yapmış olduğunuz gözlemler sonucunda dikdörtgeni herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

7) Dikdörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

8) Yeni bir Geogebra dosyası açınız ve bir dikdörtgenin özelliklerini düşünerek bir dikdörtgen oluşturunuz. Adınız soyadınızı dosyanın adına vererek masaüstüne kaydediniz.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of rectangles and students note these as properties of rectangles on their note book. Teacher expects from students to given an example about rectangle which they saw in their daily life.

Part 4

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of square.

Beginning (10 min)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that " Today, again we are going to talk about special kind of quadrilaterals called square."

During (50 min)

It is wanted from students to open GeoGebra file called "Dörtgenler 2".Then, it is wanted from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 4

a) Bilgisayarınızda **Dörgenler 1** isimli GeoGebra dosyasını açınız.

b) Yandaki sürgüyü kullanarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

2) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

3) Yapmış olduğunuz gözlemler sonucunda karenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

4) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin kare olabilmesi için hangi şartları sağlaması gerekir?

5) Yapmış olduğunuz gözlemler sonucunda kareyi herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

6) Karenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

7) Yeni bir Geogebra dosyası açınız ve bir karenin özelliklerini düşünerek bir kare oluştuşturunuz. Dosyayıyı adınız soyadınızı yazarak masaüstüne kaydediniz.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min) (20 min)

The teacher repeats what they did during the activity and answers each question.After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about square which they saw in their daily life.

Part 5

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of rhombus.

Beginning (10 min)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that " Today, again we are going to talk about special kind of quadrilaterals called rhombus."

During (20 min)

It is wanted from students to open GeoGebra file called "Dörtgenler 2".Then, it is wanted from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 5

a) Bilgisayarınızda **Dörgenler 2** isimli GeoGebra dosyasını açınız.

b) Yandaki sürgüyü kullanarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

2) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

3) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

4) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin eşkenar dörtgenin olabilmesi için hangi şartları sağlaması gerekir?

5) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

6) Eşkenar dörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

7) Yeni bir Geogebra dosyası açınız ve bir eşkenar dörtgenin özelliklerini düşünerek bir eşkenar dörtgen oluşturunuz. Oluşturduğunuz dosyaya adınızı soyadınızı vererek masaüstüne kaydediniz.

During the lessons, teacher observes what they do and takes note about their behavior

Closure (20 min) (10 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about rhombus which they saw in their daily life

Part 6

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of trapezoid.

Beginning

Remind students of what they learned in previous lessons. It can be remembered general properties of rhombus to students and then it is said that “Today, again we are going to talk about special kind of quadrilaterals called trapezoid.”

During

It is expected from students to open GeoGebra file called “Dörtgenler 2”.Then, it is wanted from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 6

a) Bilgisayarınızda **Dörgenler 2** isimli GeoGebra dosyasını açınız.

b) Yandaki sürgüyü kullanarak gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

1) Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

2) Yapmış olduğunuz gözlemler sonucunda yamuğun açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

3) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin yamuk olabilmesi için hangi şartları sağlaması gerekir?

4) Yapmış olduğunuz gözlemler sonucunda yamuğun herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

5) Yamuğun genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

6) Yeni bir Geogebra dosyası açınız ve bir yamuğun özelliklerini düşünerek bir yamuk oluşturunuz. Oluşturduğunuz dosyaya adınızı soyadınızı vererek masaüstüne kaydediniz.

During the lessons, teacher observes what they do and takes note about their behaviour and thinking.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of trapezoid and students note these as properties of trapezoid on their note book. Teacher wants from students to given an example about trapezoid which they saw in their daily life.

Part 7

During: 2 Lesson Hour

Objective: Students should be able to construct special kind of quadrilaterals.

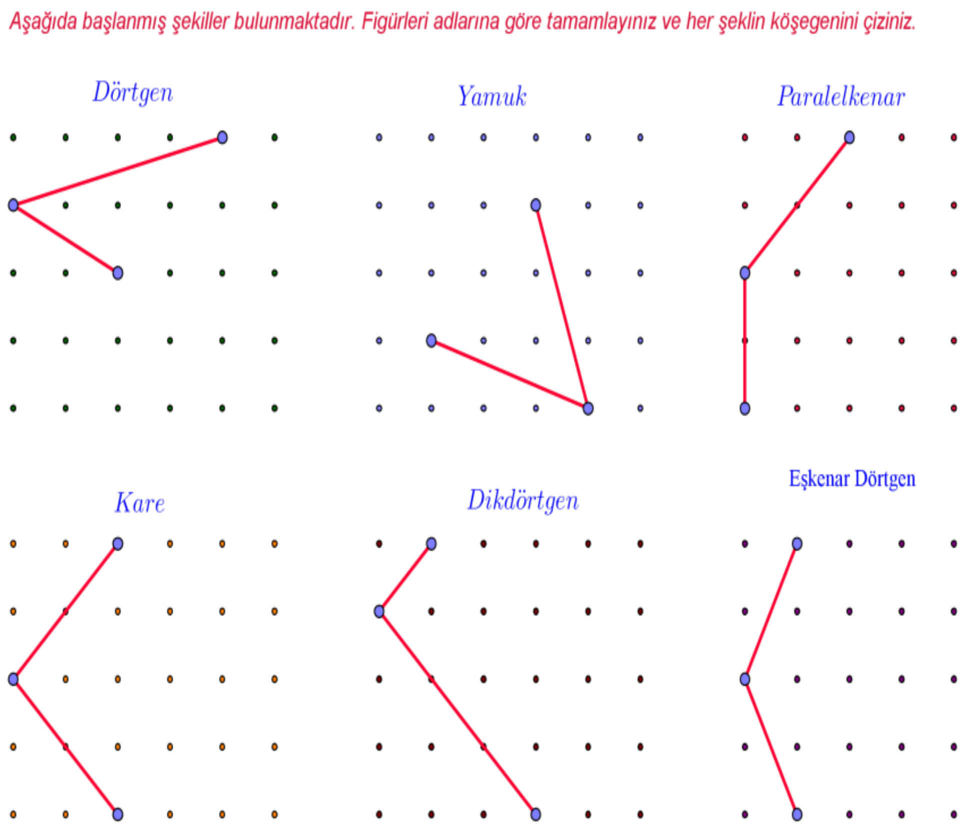
Beginning (10 min)

It is mentioned common properties of quadrilaterals at the beginning of the lesson. Then, it is moved on the activity sheet on Geogebra.

During (50 dk)

Complete the following activity both GeoGebra screen and dot paper.

Çalışma Yaprağı



After giving enough time, it is expected from students to do each question on the board, disccuss friends and summarize the properties of quadrilateral and what they do a whole topic.

Closure (20 min) (20 min)

It is asked to students whether they like the topic and treatments.

APPENDIX D

LESSON PLANS FOR CONCRETE MANIPULATIVE USED CLASS

Purpose:

These lessons are designed to introduce students to general properties of quadrilaterals. Included in this lesson are discussions of properties of quadrilaterals such as parallelograms, rectangles, square, rhombus and trapezoids.

During:

14 lesson hours

Objectives:

After this lesson, students should be able to

- be familiar with properties of quadrilaterals.
- construct particular quadrilaterals based on specific characteristics of the quadrilaterals.

Student Prerequisites:

- *Geometric:* Students must be able to:
  - recognize the general shape of a square and a rectangle.
  - recall information about angles (particularly right angles), parallel lines, and possibly the concept of congruency.
  - have an idea about usage concrete manipulatives especially geometry strip and geoboard.

Key Terms: Quadrilateral, congruent, parallel, right angle, acute angle, obtuse angle, rectangle, square, parallelogram, rhombus,t rapezoid.

Part 1:

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of quadrilaterals.

Beginning (10 min.) It is reminded students to what they learned in previous lessons that will be related to this lesson and/or have them begin to think about the words and ideas of future lessons such that

It can be repeated general properties of triangle and it is emphasized triangle is a kind of polygon. Then, it is mentioned that what they will be doing and learning today such that "Today, class, we will be talking more about the four-sided figures, called quadrilaterals. What do you know about quadrilaterals? Can you give an example about quadrilaterals in your daily life?"

During (50 minutes)

It is wanted from students to move on Çalışma Yaprağı 1.

Çalışma Yaprağı 1

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekili yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz

1) Oluşturduğunuz dörtgenlerin kenarlarının birbiriyle durumu hakkında ne söylenebilirsiniz? Sizce oluşturduklarınızın dışında hangi durumlar olabilir? Açıklayınız.

2) Oluşurtuğunuz dörtgenlerin kenar uzunlukları arasında bir ilişki var mıdır? Herhangi bir ilişki olabilir mi sizce? Açıklayınız.

3) Oluşturduğunuz dörtgelerin açı ölçüleri arasında bir ilişki var mıdır? Herhangi bir ilişki olabilir mi sizce? Açıklayınız.

During the activiy, teacher observes what students did, and their behaviour. It is expected from students to notice the properties of each constructed quadrilaterals (measure of the length of sides and diagonals and measure of and angles of each quadrilateral) and to draw these shapes on their paper (In this way; it is aim to construct quadrilaterals with different angles and lengths and be familiar with different quadrilaterals.)

Closure (20 min)

It is allowed students to work several groups (in each 5 students exist) to share what they found. Then it is wanted them to summarize in each group what we learned this lesson such that he or she explains that the quadrilateral on the screen will always remain as a quadrilateral, even though you move the sides and corners. Then, teacher summarizes the activity.

Part 2

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of parallelograms.

Beginning (10 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of quadrilaterals to students and then it is said that “Today we are going to talk about special kind of quadrilaterals called parallelogram.”

During

It is expected from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 2

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekili yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

9) Yapmış olduğunuz gözlemler sonucunda sizce paralelkenar bir dörtgen midir? Açıklayınız.

10) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

11) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

12) Yapmış olduğunuz gözlemler sonucunda paralelkenarın açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

13) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin paralelkenar olabilmesi için hangi şartları sağlaması gerekir?

14) Yapmış olduğunuz gözlemler sonucunda paralelkenarı herhangi bir dörtgendenn ayıran özellik veya özellikler nelerdir? Açıklayınız.

15) Paralelkenraın genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

16) Önünüzdeki noktalı kağıda paralelkenar çiziniz ve adınız soyadınız tüm kağıtlara yazınız.

During the lessons, teacher observes what they did and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of parallelogram and students note these as properties of parallelogram on their note book. It is wanted from students to given example about parallelogram which they saw in their daily life.

Part 3

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of rectangle.

Beginning (10 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of parallelogram to students and then it is said that “Today, again we are going to talk about special kind of quadrilaterals called rectangle.”

During (50min)

Çalışma Yaprağı 3

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekili yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

9) Yapmış olduğunuz gözlemler sonucunda sizce dikdörtgen bir dörtgen midir? Açıklayınız.

10) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

11) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız.

12) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

13) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin dikdörtgen olabilmesi için hangi şartları sağlaması gerekir?

14) Yapmış olduğunuz gözlemler sonucunda dikdörtgeni herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

15) Dikdörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

16) Önünüzdeki noktalı kağıda adınız soyadınızı yazarak dikdörtgen çiziniz.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of rectangles and students note these as properties of rectangles on their note book. Teacher wants from students to given an example about rectangle which they saw in their daily life.

Part 4

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of square.

Beginning (10 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that “ Today, again we are going to talk about special kind of quadrilaterals called square.”

During

Çalışma Yaprağı 4

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekili yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

8) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

9) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

10) Yapmış olduğunuz gözlemler sonucunda karenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

11) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin kare olabilmesi için hangi şartları sağlaması gerekir?

12) Yapmış olduğunuz gözlemler sonucunda kareyi herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

13) Karenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

14) Önünüzdeki noktalı kağıda kare çiziniz ve oher kağıda adınız soyadınızı yazınız.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about square which they saw in their daily life.

Part 5

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of rhombus.

Beginning (15 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that “ Today, again we are going to talk about special kind of quadrilaterals called rhombus.”

During (50 min)

It is wanted from students to open GeoGebra file called “Dörtgenler 2”.Then, it is wanted from students to do activity sheet 2 distributed them by their teacher.

Çalışma Yaprağı 5

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekili yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

1) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

2) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

3) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

4) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin eşkenar dörtgenin olabilmesi için hangi şartları sağlaması gerekir?

5) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

6) Eşkenar dörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

7) Önünüzdeki noktalı kağıda eşkenar dörtgenin özelliklerini düşünerek bir eşkenar dörtgen çiziniz ve tüm kağıtlara adınızı soyadınızı yazınız.

During the lessons, teacher observes what they do and takes note about their
During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about rhombus which they saw in their daily life

Part 6

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of trapezoid.

Beginning (15 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of rhombus to students and then it is said that "Today, again we are going to talk about special kind of quadrilaterals called trapezoid."

During

Çalışma Yaprağı 6

Geometri şeritleri ve geometri tahtası ile öğretmenin göstermiş olduğu şekli yapınız. Daha sonra oluşturduğunuz şeklin özelliğini bozmadan, şekli köşe noktalarından çekerek gözlemler yapınız ve aşağıdaki sorulara gözlemleriniz doğrultusunda cevap veriniz.

7) Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

8) Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

9) Yapmış olduğunuz gözlemler sonucunda yamuğun açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

10) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin yamuk olabilmesi için hangi şartları sağlaması gerekir?

11) Yapmış olduğunuz gözlemler sonucunda yamuğun herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

12) Yamuğun genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

13) Önünüzdeki noktalı kağıda yamuğun özelliklerini düşünerek bir yamuk çiziniz ve tüm kağıtlara adınızı soy isminizi yazınız.

During the lessons, teacher observes what they do and takes note about their behaviour and thinking.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of trapezoid and students note these as properties of trapezoid on their note book. Teacher wants from students to given an example about trapezoid which they saw in their daily life.

Part 7

During: 1 Lesson Hour

Objective: Students should be able to construct special kind of quadrilaterals.

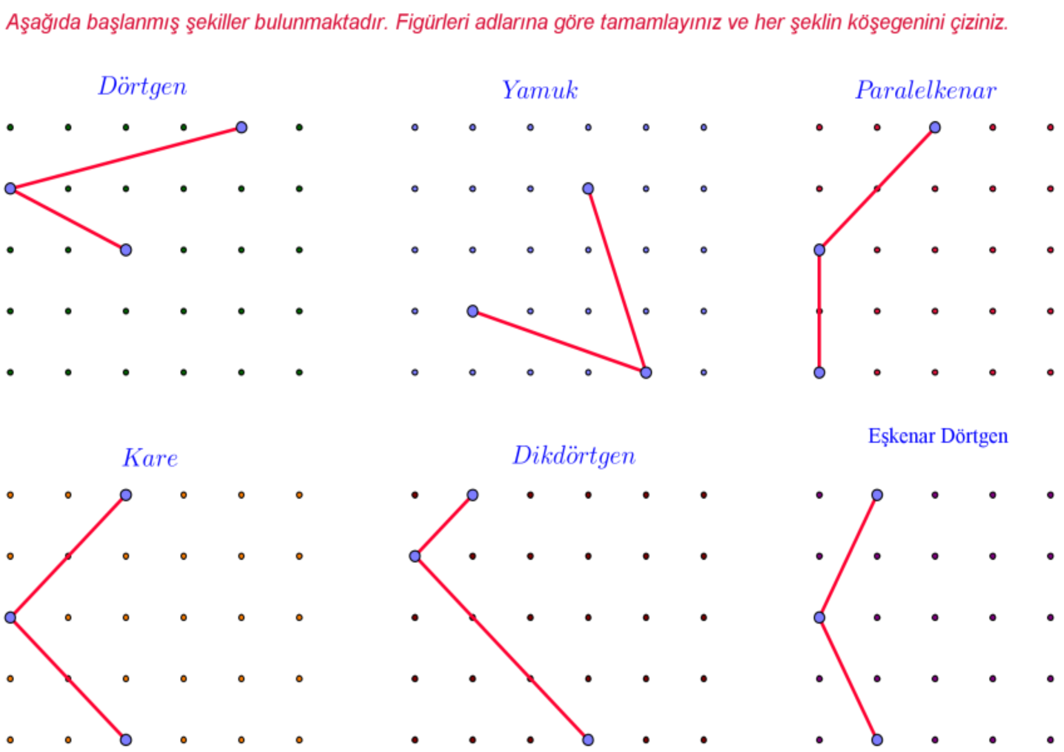
Beginning (10 min)

It is mentioned common properties of quadrilaterals at the beginning of the lesson. It is mentioned common properties of quadrilaterals at the beginning of the lesson. Then, it is moved on the activity sheet.

During (50 min)

Complete the following activity on dot paper and construct there rectangle with using geometry strip.

Çalışma Yaprağı



After giving enough time, it is expected from students to do each question on the board, discuss friends and summarize the properties of quadrilateral and what they do a whole topic.

Closure (20 min)

It is asked to students whether they like the topic and treatments.

APPENDIX E

LESSON PLANS FOR TRADITIONAL MATERIAL USED CLASS

Purpose:

These lessons are designed to introduce students to general properties of quadrilaterals. Included in this lesson are discussions of properties of quadrilaterals such as parallelograms, rectangles, square, rhombus and trapezoids.

During:

14 lesson hours

Objectives:

After this lesson, students should be able to

- be familiar with properties of quadrilaterals.
- construct particular quadrilaterals based on specific characteristics of the quadrilaterals.

Student Prerequisites:

- *Geometric:* Students must be able to:
  - recognize the general shape of a square and a rectangle.
  - recall information about angles (particularly right angles), parallel lines, and possibly the concept of congruency.
  - have an idea about usage protractor, ruler and dot paper.

Key Terms:

This lesson introduces students to the following terms through the included discussions:

Quadrilateral, congruent, parallel, right angle, acute angle, obtuse angle, rectangle, square, parallelogram, rhombus, trapezoid.

Part 1:

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of quadrilaterals.

Beginning (10 min.)

It is reminded students to what they learned in previous lessons that will be related to this lesson and/or have them begin to think about the words and ideas of future lessons such that

It can be repeated general properties of triangle and it is emphasized triangle is a kind of polygon. Then, it is mentioned that what they will be doing and learning today such that "Today, class, we will be talking more about the four-sided figures, called quadrilaterals. What do you know about quadrilaterals? Can you give an example about quadrilaterals in your daily life?"

During (50 minutes)

It is expected from students to move on Çalışma Yaprağı 1.

Çalışma Yaprağı 1

İkinci kağıtta çeşitli dörtgen şekilleri çizilmiştir ve dörtgenlerin kenar uzunlularını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni dörtgen çiziniz.

1. Oluşturduğunuz dörtgenlerin kenarlarının birbiriyle durumu hakkında ne söylenebilirsiniz? Sizce oluşturduklarınızın dışında hangi durumlar olabilir? Açıklayınız.

Part 2

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of parallelograms.

Beginning (10 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of quadrilaterals to students and then it is said that "Today we are going to talk about special kind of quadrilaterals called parallelogram."

During

It is expected from students to do activity sheet 2 by making observation on given examples.

Çalışma Yaprağı 2

Diğer kağıtta çeşitli paralelkenar şekilleri çizilmiştir ve dörtgenlerin kenar uzunlularını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni paralelkenar çiziniz..

17) Yapmış olduğunuz gözlemler sonucunda sizce paralelkenar bir dörtgen midir? Açıklayınız.

18) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

19) Yapmış olduğunuz gözlemler sonucunda paralelkenarın karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

20) Yapmış olduğunuz gözlemler sonucunda paralelkenarın açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

21) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin paralelkenar olabilmesi için hangi şartları sağlaması gerekir?

22) Yapmış olduğunuz gözlemler sonucunda paralelkenarı herhangi bir dörtgendenn ayıran özellik veya özellikler nelerdir? Açıklayınız.

23) Paralelkenraın genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

24) Önünüzdeki noktalı kağıda paralelkenar çiziniz ve adınız soyadınız tüm kağıtlara yazınız.

During the lessons, teacher observes what they did and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of parallelogram and students note these as properties of parallelogram on their note book. It is wanted from students to given example about parallelogram which they saw in their daily life.

Part 3

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of rectangle.

Beginning (10min)

Remind students of what they learned in previous lessons. It can be remembered general properties of parallelogram to students and then it is said that "Today, again we are going to talk about special kind of quadrilaterals called rectangle."

During (50 min)

Çalışma Yaprağı 3

Diğer kağıtta çeşitli dörtgen şekilleri çizilmiştir ve dikdörtgenlerin kenar uzunlularını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni dikdörtgen çiziniz..

17) Yapmış olduğunuz gözlemler sonucunda sizce dikdörtgen bir dörtgen midir? Açıklayınız.

18) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

19) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

20) Yapmış olduğunuz gözlemler sonucunda dikdörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

21) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin dikdörtgen olabilmesi için hangi şartları sağlaması gerekir?

22) Yapmış olduğunuz gözlemler sonucunda dikdörtgeni herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

23) Dikdörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

24) Önünüzdeki noktalı kağıda adınız soyadınızı yazarak dikdörtgen çiziniz.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of rectangles and students note these as properties of rectangles on their note book. Teacher wants from students to given an example about rectangle which they saw in their daily life.

Part 4

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of square.

Beginning (15 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that " Today, again we are going to talk about special kind of quadrilaterals called square."

During

Çalışma Yaprağı 4

İkinci kağıtta çeşitli kare şekilleri çizilmiştir ve karelerin kenar uzunluklarını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni kare çiziniz..

15) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

16) Yapmış olduğunuz gözlemler sonucunda karenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

17) Yapmış olduğunuz gözlemler sonucunda karenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

18) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin kare olabilmesi için hangi şartları sağlaması gerekir?

19) Yapmış olduğunuz gözlemler sonucunda kareyi herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

20) Karenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

21) Önünüzdeki noktalı kağıda kare çiziniz ve oher kağıda adınız soyadınızı yazınız.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about square which they saw in their daily life.

Part 5
During: 2 Lesson Hours
Objective: Students should be able to recognize general properties of rhombus.
Beginning (10 min)

Remind students of what they learned in previous lessons. It can be remembered general properties of rectangle to students and then it is said that " Today, again we are going to talk about special kind of quadrilaterals called rhombus."

During (50 min)

Çalışma Yaprağı 5

İkinci kağıtta çeşitli eşkenar dörtgen şekilleri çizilmiştir ve dörtgenlerin kenar uzunlularını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni eşkenar dörtgen oluştuşturunuz.

8) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

9) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız..

10) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

11) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin eşkenar dörtgenin olabilmesi için hangi şartları sağlaması gerekir?

12) Yapmış olduğunuz gözlemler sonucunda eşkenar dörtgenin herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

13) Eşkenar dörtgenin genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

14) Önünüzdeki noktalı kağıda eşkenar dörtgenin özelliklerini düşünerek bir eşkenar dörtgen çiziniz ve tüm kağıtlara adınızı soyadınızı yazınız.

During the lessons, teacher observes what they do and takes note about their behavior.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of square and students note these as properties of squares on their note book. Teacher wants from students to given an example about rhombus which they saw in their daily life

Part 6

During: 2 Lesson Hours

Objective: Students should be able to recognize general properties of trapezoid.

Beginning (10 min.)

Remind students of what they learned in previous lessons. It can be remembered general properties of rhombus to students and then it is said that "Today, again we are going to talk about special kind of quadrilaterals called trapezoid."

During

Çalışma Yaprağı 6

İkinci kağıtta çeşitli yamuk şekilleri çizilmiştir ve dörtgenlerin kenar uzunlularını açılarını ölçerek gözlemler yapınız. Yapmış olduğunuz gözlemler sonucu 5 yeni yamuk çiziniz.

14) Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlarının durumu hakkında ne söylenebilir? Açıklayınız.

15) Yapmış olduğunuz gözlemler sonucunda yamuğun karşılıklı kenarlar uzunlukları arasında bir ilişki var mıdır? Açıklayınız.

16) Yapmış olduğunuz gözlemler sonucunda yamuğun açı ölçüleri arasında bir ilişki gözlemliyorsunuz? Açıklayınız.

17) Yapmış olduğunuz gözlemler sonucunda sizce bir dörtgenin yamuk olabilmesi için hangi şartları sağlaması gerekir?

18) Yapmış olduğunuz gözlemler sonucunda yamuğun herhangi bir dörtgenden ayıran özellik veya özellikler nelerdir? Açıklayınız.

19) Yamuğun genel özelliklerini sıra arkadaşınızla tartışınız. Daha sonra düşündüklerimizi tüm sınıfla paylaşalım.

20) Önünüzdeki noktalı kağıda yamuğun özelliklerini düşünerek bir yamuk çiziniz ve tüm kağıtlara adınızı soy isminizi yazınız.

During the lessons, teacher observes what they do and takes note about their behaviour and thinking.

Closure (20 min)

The teacher repeats what they did during the activity and answers each question. After discussion, teacher summarizes general properties of trapezoid and students note these as properties of trapezoid on their note book. Teacher wants from students to given an example about trapezoid which they saw in their daily life.

Part 7

During: 1 Lesson Hour

Objective: Students should be able to construct special kind of quadrilaterals.

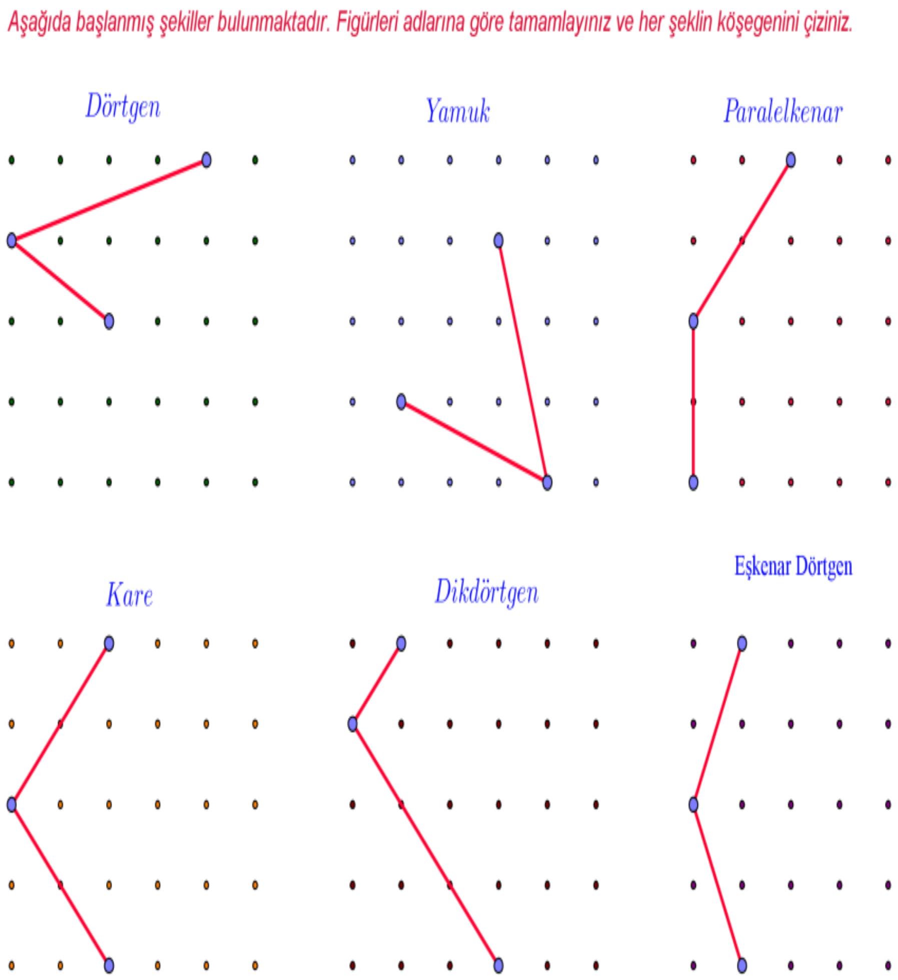
Beginning (10 min)

It is mentioned common properties of quadrilaterals at the beginning of the lesson.

During (50 min)

Complete the following activity on dot paper and construct wanted quadrilateral with using ruler and pencil.

Çalışma Yaprağı



After giving enough time, it is wanted from students to do each question on the board. After giving enough time, it is expected from students to do each question on the board, disccuss friends and summarize the properties of quadrilateral and what they do a whole topic.

Closure (20 min)

It is asked to students whether they like the topic and treatment.

APPENDIX F

TURKISH SUMMARY/TÜRKÇE ÖZET

GEOGEBRA VE SOMUT MATERYAL KULLANIMININ BEŞİNCİ SINIF ÖĞRENCİLERİNİN DÖRTGENLER KONUSUNDAKİ BAŞARISI ÜZERİNDE ETKİSİ

Geometri, matematik eğitiminin en önemli yapıtaşlarından biridir (NCTM, 1991). Geometri öğrenimi, öğrencilere çevrelerini anlama, analiz etme, yorumlama gibi temel beceriler kazandırır (NCTM, 2000). Öğrenciler, çevrelerindeki iki ve üç boyutlu cisimleri, geometri yardımı ile gözlemleyebilir ve analizler yapabilir (Battista, 2007). Geometri öğretimi bir çok alanda farklı amaçlar için kullanılır (Laborde, Kynigos, & Strasser, 2006). Aynı şekilde, geometri öğretimi okul matematiğinde de önemli bir yer kaplar. Bunu paralel olarak merkezi ve ulusulararası sınavlarda geometri önemli rol oynar. Ancak bir çok ulusal ve uluslararası çalışma, öğrencilerin geometri alanında çok başarılı olmadığını göstermektedir (Mullis et al., 2004). Örneğin uluslararası sınavlardan olan PISA ve TIMSS 2015 sonuçlarına göre, Türkiye'deki öğrenciler geometri alanında uluslararası ortalamanın oldukça altındadır (Ubuz, Üstün & Erbaş, 2009). Benzer şekilde, LYS verilerine göre (Liseye Giriş Sınavı) de öğrenciler geometride oldukça düşük başarı göstermektedir. Örneğin, LYS 2016 sonuçlarına göre 30 geometri sorusunun ortalaması, 4,22'dir. Bu verilere dayanarak öğrencilerin geometri konusunda ciddi zorluklar yaşadığı söylenebilir. Öğrencilerin yanı sıra öğretmenler de geometri öğretimi konusunda belli başlı zorluklar yaşamaktadırlar. Yeni matematik müfredatında farklı materyaller kullanarak geometri kullanımını desteklenmektedir (MEB, 2013). Öğrenme ortamları ve derslerde kullanılan malzemeler, geometri eğitiminde amaçlara ulaşmada önemli bir rol oynayan öğretmenlerin geometriyi öğretirken somut materyalleri ve dinamik yazılımları kullanmaları önerilir. Somut materyaller, öğrencinin matematiksel kavramları ve özelliklerini kavrayabilmesi için tasarlanmış bir fiziksel nesne olarak tanımlanabilir (Bouck & Flanagan, 2010; Suh & Moyer, 2008). Somut materyal kullanımı, öğrencilere matematiksel konseptler hakkında fikir sahibi olmaları sağlar. Bunu yanı sıra, matematik derslerinde somut materyal kullanımı öğrencilerin kavramsal algılamasını ve anlamasını ve matematiksel sembollerle gerçek hayat durumları arasında bir bağ kurmasını kolaylaştırır (Heddens, 2005). Yapılmış bir çok çalışmada da, derslerde somut materyal kullanımının, matematik öğrenimde pozitif bir etkiye sahip olduğunu göstermektedir (Beougher, 1967; Brousseau, 1973; Burns, 2006; Heddens, 2007). Benzer şekilde, somut material kullanımı duyu organları ile desteklenmesi sonucunda hem öğrencileri motive eder hem de zengin bir öğrenme ortamı oluşturur (Castro, 2006; Driscoll, 1981; Sowell, 1989; Suydam, 1986). Somut materyal kullanımının yanı sıra, teknolojinin eğitime entegrasyonu ile geometri öğretimi farklı bir boyut kazanmıştır. Teknolojinin eğitime entegrasyonun bir parçası olarak dinamik geometri yazılımları düşünebilir. Yapılmış bir çok çalışma dinamik geometri yazılımlarının matematik öğretiminde ve öğreniminde olumlu bir etkiye sahip oluduğunu göstermektedir (Çağıltay, Çakıroğlu, Çağıltay, & Çakıroğlu, 2001; Myers, 2009; Sauter, 2001; Smith, 2010; Tayan, 2011; Ubuz, Üstün, & Erbaş, 2009). Dinamik geometri yazılımlarından biri ve en çok kullanılanı GeoGebra'dır. GeoGebra cebir ve geometri gibi belli başlı matematik alanlarını birleştiren bir dinamik geometri yazılımı türüdür (Hohenwarter & Preiner, 2007). GeoGebra programı temel bilgisayar becerileri ile kullanılabilen, ücretsiz bir dinamik geometri yazılımının türüdür. Birçok çalışma, GeoGebra ve diğer Dinamik Geometri yazılımlarının kullanımın matematiksel kavramları görselleştirmesine yardımcı olduğunu ve dinamik yapıları sayesinde öğrencilerin öğrenme süreçlerine olumlu bir çok katkısı olduğunu gösterir. Dörtgenler ve dörtgenlerin temel özelliklerinin belirlenmesi, geometri öğretiminde iki önemli konudur çünkü anaokulundan yüksek öğretime kadar tüm seviyelerde önemli yer kaplar (MEB, 2013). İki önemli konu olmasının yanı sıra, geometri de öğrencilerin en çok zorlandığı da konulardır (Fujita & Jones, 2007; Vinner, 1991; Zaslavsky, & Shir, 2005).

Yukarıda bahsedilen çalışmaların ışığı altında bu çalışmanın amacı, aktiviteye dayalı somut materyal kullanmarak öğrenmenin ve aktiviteye dayalı GeoGebra kullanarak öğrenmenin sadece aktiviteye dayalı öğrenme ile kıyaslandığında 5. sınıf öğrencilerinin dörtgenler konusunda başarısına etkisini incelemektir. Diğer amaç ise, kullanılan materyallerin (GeoGebra ve somut materyal) öğrencilerin açıklamaları üzerine etkisini yarı yapılandırılmış görüşmeler yoluyla derinlemesine incelemektir.

Çalışmanın araştırma soruları aşağıdaki gibi belirtilmiştir:

- Öğrencilerin ön test sonuçlarını kontrol ettikten sonra, aktiviteye dayalı somut materyal kullanarak öğrenmenin ve aktiviteye dayalı GeoGebra kullanarak öğrenmenin sadece aktiviteye dayalı öğrenme ile kıyaslandığında 5. sınıf öğrencilerinin dörtgenler konusunda başarısına etkisi nelerdir?
- Öğrencilerin ön test sonuçlarını kontrol ettikten sonra, aktiviteye dayalı somut materyal kullanarak öğrenmenin sadece aktiviteye dayalı öğrenme ile kıyaslandığında dörtgenler başarı testi açısından öğrencilerin başarılarına etkisi var mıdır?
- Öğrencilerin ön test sonuçlarını kontrol ettikten sonra, aktiviteye dayalı GeoGebra kullanarak öğrenmenin ve sadece aktiviteye dayalı öğrenme ile kıyaslandığında dörtgenler başarı testi açısından öğrencilerin başarılarına etkisi var mıdır?
- Öğrencilerin dörtgenlerle ilgili açıklamaları ve soruları çözüm biçimleri kullanılan materyallere göre (GeoGebra ve somut materyal) nasıl değişir?

Diğer çalışmalardan farklı olarak bu çalışma kırsal bir alanda ve düşük sosyoekonomik seviyedeki öğrenci grubu ile gerçekleştirilmiştir. Çalışmaya katılan öğrencilerin çoğunun evlerinde bilgisayar bulunmamaktadır. Bu çalışmada iki deneysel ve bir kontrol grubunu içeren yarı deneysel karma araştırma deseni kullanılmıştır. Nitel tasarım için, yarı yapılandırılmış görüşme formları tercih edilmiştir. Çalışma, 2015-2016 eğitim öğretim yılının ikinci döneminde Düzce'de bir ortaokulda gerçekleştirilmiş ve 14 ders saati (3 hafta) sürmüştür. 35'i kız 25'i erkek olmak üzere 60 öğrenci çalışmanın örneklemini oluşturmaktadır. Bu öğrencilerin 19'u GeoGebra'nın kullanıldığı grupta, 20'si somut materyallin kullanıldığı grupta ve 21'i de kontrol grubunda bulunmaktadır.

Okulda bulunan üç tane 5. sınıf çalışmaya katılmışıtr. Okulda bir adet bilgisayar laboratuvarı bulunmaktadır. Bu grupları deney ve kontol grubu olarak atarken öncelikli olarak bilgisayar laboratuvarının uygun olmasına bakılmış, haftalık ders programında matematik dersi ile laboratuvarın boş olduğu saatler eşleştirilmiştir. Uygunluk durumuna göre GeoGebra kullanılcak sınıf öncelikle belirlenmiştir. Diğer deney grubu ve kontol grubu rastgele atanmıştır. Deney gruplarından birinde somut materyaller kullanılarak örneğin geometri tahtası ve geometri şeritlerini kullanılarak öğrenme ortamı oluşturulmuş ve öğrencilerden aktivite kağıdındaki sorulara bu materyallerle yaptığı gözlemler sonucu cevap vermesi beklenmiştir. Diğer deney grubunda GeoGebra kullanılarak öğrenme ortamı oluşturulmuş ve öğrencilerden aktivite kağıdındaki sorulara GeoGebra ile yaptığı gözlemler sonucu cevap vermesi beklenmiştir. Öte yandan, kontrol sınıfındaki öğrenciler için geleneksel materyaller kullanarak (açı ölçer ve cetvel) aktivite temelli öğrenme ortamı oluşturulmuştur ve öğrencilerden aktivite kağıtlarındaki sorulara geleneksel materyalleri kullanarak yaptığı gözlemler sonucu cevap vermesi beklenmiştir. Üç sınıftada aynı yöntem, aynı öğrenme ortamı ve aynı aktivite kağıtları kullanılmıştır. Tek fark öğrenme sürecinde kullanılan araçtır. Daha farklı bir deyişle, GeoGebra kullanılan grupta öğrencilerden dörtgenler konusunu işlerken önlerindeki onlar için hazırlanmış GeoGebra dosyasını açarak ve aktivite kağıdındaki yönergeleri takip ederek gözlemler yapması istenmiş ve beklenmiştir. Öğrenciler GeoGebra dosyasındaki sürgüyü çekerek farklı dörtgenler oluşturmuşlar ve oluşturdukları dörtgenlerin ismi ve özellikleri ekranda görme fırsatı edinişlerdir. Bu sayede öğrenciler örneğin bir dörtgenin paralelkenar olabilmesi için hangi özellikleri taşıması gerektiğini kendi başına keşfettiler. Daha sonra bulgularını önce sıra arkadaşı ile paylaştılar daha sonra sınıf tartılmasında dile getirme fırsatı edindiler. Bunun sonucunda paralelkenarın biçimsel tanımına kedni ve sınıf arkadaşlarının gözlemleri sonucunda ulaştılar. Başka dörtgenlerin özelliklerini keşfettikçe de daha önce çalıştıkları dörtgenlerle ortak ve farklı noktaları karşılaştırma ve kıyaslama şansı edinmişlerdir. Daha sonra yapmış oldukları gözlemlere dayanarak, çalıştıkları şekilleri günlük hayatta nerelerde rastladıklarından bahsederler. Benzer şekilde, somut materyal kullanılan grupta öğrenciler önlerinde bulunan farklı büyüklükteki ve özellikteki paralelkenarlardan yararlanarak örneğin kare ve dikdörtgen gibi geometri şeritleri ve geometri tahtası ile yapma fırsatı edinirler. Bu sayede öğrenciler oluşturdukları dörtgenler arasında bağ kurar ve özelliklerini keşfederler. Yine aynı şekilde GoeGebra kullanan grupta olduğu gibi bulgularını önce sıra arkadaşı ile sonra da sınıf tarışması ile sınıf arkadaşları ile paylaşırşar. Daha sonra çalıştıkları dörtgenin özelliklerini de içeren sınıfça bir tanım yapmışlardır. Kontrol gubunda ise, öğrenciler çalışılan dörtgenin önlerinde bulunan daha önce çizilmiş, beş farklı çeşitinin özelliklerini açı ölçer ve cetvel yardımı ile gözlemleme şansı edinirler ve not alırlar. Daha sonrası için izlenen prosedür, GeoGebra ve somut materyal kullanılan gruplardaki ile aynıdır.

Verilerin toplanabilmesi için, Usiskin (1982) ve Genç (2010) tarafından geliştirilen testlerdeki soruların kullanılmasına dayalı, araştırmacı tarafından “Dörtgenler Başarı Testi" uyarlanmıştır. Dörtgenler başarı testi uygulama başlamadan iki hafa önce ve uygulamadan üç gün sonra tüm gruplara uygulanmıştır. Bu teste 20 tane çoktan seçmeli soru, 1 tane doğru yanlış ve 4 tane de açık uçlu soru bulunmaktadır. Nicel araştırma sorularına cevaplar bulmak için, kovaryans analizi (ANCOVA) ve betimsel analiz uygulanmıştır.

Uygulamaları gerçekleştirmek için gerekli etik izinler hem öğrencilerden hem velilerden hem de okul yönetiminden alınmıştır. Çalışmanın iç ve dış geçerliliğine zarar veren durumlar en aza düşülmeye çalışılmıştır. Çalışmada nicel sonuçlar, öğrencilerin Dörtgenler Başarı Testi puanlarının ön testte birbirine benzer olduğunu ve son testte puanların gruplararası farklılaştığını göstermiştir.

Aktivite temelli GeoGebra kullanarak oluşturulan öğrenme ortamının ön test ortalaması 49.97 (*SD*=19.40) iken son test ortalaması 79.61 (*SD*=15.81)'ye yükselmiştir. Aktivite temelli somut materyal kullanarak oluşturulan öğrenme ortamının ön test ortalaması 49.43 (*SD*=15.06) iken 68.76 (*SD*=18.05)'ye yükselmiştir. Kontrol grubunun ön test ortalaması ise 46.52 (*SD*=18.34)'den 60.64 (*SD*=19.62)'ye yükselmiştir. Bu değişimin istatistiksel olarak anlamlı olup olmadığını incelemek için ANCOVA yapılmıştır. Dörtgenler Başarı Testi sonuçlarına göre $F(2,56) = 86.60$, $p=.00$. gruplararası GeoGebra kullanılan sınıf destekleyen anlamlı bir fark bulunmuştur. Diğer bir deyişle, GeoGebra kullanılan etkinlik tabanlı öğrenmenin uygulandığı grupta ve somut materyal kullanılan etkinlik temelli öğrenmenin uygulandığı gruplar arasında öğrencilerin başarısı açısında anlamlı fark vardır ($p = .02$) ve GeoGebra kullanılan aktivite tabanlı öğrenmenin gerçekleştirildiği grub ile yalnızca aktivite tabanlı öğrenme sağlanan kontrol grubu arasında öğrencilerin başarısı açısından anlamlı bir fark vardır ($p= .02$). Ancak somut materyal kullanılan aktivite temelli öğrenmenin uygulandığı grup ile yalnızca aktivite tabanlı öğrenimin uygulandığı kontrol grubu arasında öğrencilerin başarısı arasında anlamlı bir fark olmadığı ortaya çıkmıştır ($p= .32$).

Nicel verilere ek olarak, görüşmeler uygulamanın hemen ardından yapılmıştır. Bu aşamada, üç öğrencinin açıklamalarına ve cevaplarına yer verilmiştir. Bu üç öğrencinin her biri ayrı sınıftan seçilmiş olup, seçilme işlemi sürecinde daha zengin veri elde edebilmek için öğrecilerin konuşkan, görüşmeye katılmayı hevesli ve başarılı olması gibi etkenler göz önünde bulundurulmuştur. Tüm dersler ve görüşmeler video ile kayıt altına alınmıştır. Görüşmeler analiz edildiğinde GeoGebra kullanan öğrencinin daha kavramsal bilgiye sahip olduğu ve detaylı görüşler sunduğu görülmüştür. Buna ek olarak, üç gruptaki öğrencilerin derslere aktif bir şekilde katılmasına rağmen, nicel ve nitel verilerin analizleri GeoGebra kullanarak aktivite temelli öğrenme ortamının dörtgenler konusunu öğrenirken öğrenciler üzerinde pozitif bir etkiye sahip olduğunu ve öğrencilerin bakış açılarını genişlettiğini göstermektedir. Bu sonuç, literatürdeki daha önceki araştırma çalışmalarıyla da tutarlıdır (Diković, 2009; Doktoroğlu, 2013; Furkan, Zengin, & Kutluca, 2012; Furner & Marinas, 2006; Genç, 2010; Guven, 2012; Hannafin, Burruss ve Küçük, 2001; Hannafin, Truxaw, Vermillion & Liu, 2008; Healy & Hoyles, 2002; Işıksal & Askar, 2005; Pierce & Stacey, 2005; Reis & Özdemir, 2010; Reimer ve Moyer, 2005; Shadaan & Leong, 2013; Roschelle, Bezelye, Hoadley, Gordin & Means, 2000; Zulnaidi & Zakaria, 2012; Yousef, 1997; Xing, Guo, Petakovic & Goggins, 2015).

GeoGebra'yı kullanarak aktiviteye dayalı öğrenmenin öğrencilerin dörtgenler konusundaki başarısına olumlu etkilerini açıklayabilecek bazı olası nedenler vardır. Örneğin, Magruder (2012) tarafından doğrusal denklemler konusunu öğretirken manipulatif kullanmadan oluşturulan geleneksel öğrenme ortamı ile somut ve sanal manipülatiflerin kullanıldığı öğrenme ortamlarını karşılaştırmaya yönelik bir çalışma yürütülmüştür. Karma araştırma deseni ile verileri analiz edilmiş, nicel veriler için ön ve son test uygulanmıştır. Araştırmaya 76 altıncı sınıf öğrencisi katılmıştır. Nicel verilerin analizi göre, manipülatif olmayan öğrenme yöntemleri kullanılan kontrol grubunun lehine çıkmıştır. Ayrıca, grupların son test sonrası puanları arasında istatistiksel olarak anlamlı farklar olduğunu ortaya çıkmıştır. Bu yüzden söylenebilir ki çalışan konunun doğası, derste kullanılan materyalle doğrudan ilişkilidir. Bu sebeplede dörtgenler konusu bilgisayar destekli öğrenmeye daha görsel yapısından dolayı doğrusal daha uygun olduğu söylenebilir. Ayrıca, Jones (2010), GeoGebra yardımı ile şekilleri öğrenen öğrencilerin, GeoGebra kullanmayan öğrencilere göre daha kolay agıladıklarını, yapılandırdıklarını, tahmin ettiklerini ve manipüle ettiklerini belirtti. Sträßer (2001), Healy ve Hoyles (2001), GeoGebra'nın dinamik özellikleri sayesinde öğrencilerin zengin öğrenme ortamları ile bilgileri inşa ettiklerini belirtti. Bu sonuç, teknolojik (DGS kullanan) ve teknolojik olmayan ortamlarda (geleneksel araçları kullanarak) geometri üzerinde çalışan 8. sınıf öğrencilerinin argümanlarını karakterize eden ve karşılaştıran Smith'in (2010) sonuçlarıyla tutarlıdır. Çalışmanın sonuçları, teknolojik ortamlarda eğitim gören öğrencilerin, teknolojik olmayan ortamlarda eğitim gören öğrencilere kıyasla, daha fazla argüman geliştirdiklerini ve daha fazla veri topladıklarını ortaya koydu. Bu nedenle, öğretmenlerin dinamik özelliklere sahip teknolojik araçlarla etkinlik ve ders tasarlama konusunda yıllık ve günlük planlarında daha fazla yer ayırmaları gerektiğini belirtti.

Her gruptaki öğrenciler aynı aktivite kağıdı ile çalışmasına rağmen, uygulama süresince GeoGebra, geometri şeridi, geometri tahtası, cetvel ve açı ölçer gibi farklı materyaller kullandılar. Açı ölçer ve cetvel kullanan grup çalışma sırasında çok sayıda dörtgenin özelliğini inceleyemedi, çünkü çalışma sayfalarında çaılışılan dörtgenin yalnızca beş farklı türü ve ebatı mevcuttu.Geleneksel malzemeleri kullanan öğrenciler (açı ölçer ve cetvel) dörtgenleri manipulate etme şansına sahip değildi. Bununla birlikte, somut materyal ve GeoGebra kullanan öğrenciler, hem görsel olarak zengin ve eğlenceli öğrenme ortamlarına sahip oldular hem de dörtgenlerin boyut, uzunluk ve alan özelliklerini değiştirme ve manipule etme fırsatı buldular. Buna ek olarak, GeoGebra ve somut materyal kullanan deney gruplarındaki öğrenciler, kağıt, kurşun kalem, cetvel ve açı ölçer kullanan kontrol grubu öğrencilerine kıyasla nesneleri farklı açılardan inceleme ve gözlemleme şansına sahip oldular (Aarnes & Knudtzon, 2003). Bu tür gözlem ve keşifler, öğrencilerin incelenen şeklin önemli detaylarını ve özelliklerini kavrayabilmelerine yardımcı olurlar (Akgül, 2014). Geleneksel materyalleri kullanan öğrenciler statik çizimlerle uğraşırken, GeoGebra kullanan öğrenciler saniyeler içinde istenilen dörtgeni oluşturken ve geometri tahtası ve geometri şeritleri kullanan öğrenciler birkaç dakika içinde istenilen şekilleri oluşturdular. Öte yandan, somut materyal kullanan öğrenciler de GeoGebra'yı kullanan öğrencilere kıyasla daha sınırlı sayıda dörtgen üzerinde çalıştı. Ders işleyişi her üç grup için de öğrencilerin aktif olarak katılımını sağlayacak şekilde tasarlandı. GeoGebra'yı sınıflarında kullanan öğrenciler, üç grubun en şanslısıydı, çünkü GeoGebra'yı kullanarak daha fazla keşif ve gözlem yapabildiler Farklı şekilde ifade etmek gerekirse, GeoGebra'yı kullanan deney grubu, diğer gruplardan daha fazla dörtgen oluşturma ve gözlemleme şansı edindi. Bu durumda onların (daha çok gözlem yapmaları) dörtgenleri daha iyi anlamalarına ve tartışmalara daha fazla katılmalarına yardımcı oldu. Benzer şekilde, kavramsal soruları analizinden elde edilen bulgular, GeoGebra yoluyla öğrenen öğrencilerin diğer deney grubundaki ve kontrol grubundaki öğrencilerden dörtgenlerin özelliklerini keşfetmede daha başarılı olduklarını gösterdi. Öğrencilerin GeoGebra sınıflarındaki dörtgenlerdeki en yüksek başarısının altında yatan bir diğer nedeni, bilgisayarın kullanılması olabilir; bu da, dinamik yazılım kullanarak öğrencilere matematik derslerinin daha heyecan verici ve ilginç olmasını sağlayabilir. Uygulama sırasında da, GeoGebra'yı kullanan öğrencilerin, araştırmaya katılan diğer öğrencilere kıyasla derslere daha istekli bir şekilde katıldığı görülmüştür. Daha önce de belirtildiği gibi okuldaki öğrencilerin birçoğu düşük sosyoekonomik statüye sahiptiler ve çoğunun evde bilgisayarı bulunmamaktaydı. Bu sebeple öğrenciler GeoGebra yardımıyla gözlem yaparken bilgisayarla da vakit geçirirme fırsatı elde ettiler. Etkinlikler sırasında da oldukça heyecanlı oldukları görüldü. Furner ve Marinas (2006) ve Choate (1992), öğrencilerin dinamik bir öğrenme ortamında etkinlikleri öğrenmeye daha istekli olduklarını vurgulamışlardır. Benzer şekilde teknolojik gelişmeler, öğrencilerin ilgisini somut materyallerden veya geleneksel materyallerden daha fazla çekebilir (Bates & Poole, 2003).

GeoGebra kullanılan sınıfta daha yüksek ortalamanın çıkmasının altında yatan diğer bir sebep, aktiviteler içerisinde sorulara harcanan zaman olarak düşünülebilir. Deney gruplarından biri olan somut materyal kullanılan grupta öğrenciler somut materyalleri toplamak, istenilen şekilleri oluşturmak, istedikleri şekli yapmak gibi nedenlerle ve kontrol grubundaki öğrenciler de açı ölçer kullanarak açı ölçmek gibi nedenlerden dolayı aktivite süresince belli zaman kaybettiler. Ancak diğer bir deney grubunda bulunan öğrenciler GeoGebra'nın sürükleme özelliği sayesinde hiç zaman kaybetmeden diğer gruplardaki öğrencilere kıyasla çok daha fazla sayıda ve çeşitte dörtgenlerle gözlem yapabilme şansı edindiler. Üstelik GeoGebra'nın bu sürükleme özelliği sayesinde öğrenciler nesneleri yeniden boyutlandırıp manipüle etme, değişiklikleri izleme, hipotezleri test etme ve bazı şekiller hakkında genelleme yapma şansı yakaladılar. Literatürdeki pek çok çalışma, dinamik öğrenme ortamının, öğrencilerin geometri eğitiminde kavramsal anlayış inşa etmesine yardımcı olan matematiksel fikirleri ve kavramları görselleştirmesine olanak tanıyan bir araç olduğunu görüşünü de destekler (Battista, 1994; Gutiérrez, 1996; Hacıömeroğlu, 2011; Harnisch , 2000; Yılmaz, Argün & Keskin, 2009). Benzer şekilde, Hohenwarter ve ark. (2008) GeoGebra'nın öğrencilerin kavramları daha ayrıntılı olarak görselleştirme şansı sağladığını ve bu sayede öğrencilerin daha iyi anlamalarını ve anlamlandırmalarını sağlamasına katkıda buluduğunu belirtti. Merve (GeoGebra sınıfından görüşmeye katılan öğrenci) sorulara verdiği cevaplarda ezber tanımlar yapmak yerine, GeoGebra kullanarak aktivitelere cevap verirken edindiği deneyimlerinden görüşme sırasında sıkça bahsetti ve bu deneyimler onun uygulama sırasında yaptığı izlediği prosedürleri gözünde canlandırıp cevaplar vermesine yardımcı oldu.

Ayrıca nicel verilere ek olarak nitel veriler de gösterdi ki, GeoGebra'yı kullanan öğrenciler dörtgenlerin özellikleri arasında bağlantılar kurdu ve dörtgenlerin özelliklerini ve tanımlarını ezberlemek yerine kendi kelimeleri ile dörtgeni tanımladı ve kendi deneyimlerine dayanarak çıkarımlar yaptı. Merve (GeoGebra kullanarak öğrenen) uygulama sonunda dörtgenleri tanımlarken daha kavramsal ifadeler kullandı ve dörtgenler arasındaki ilişkilerden diğer katılımcılara göre daha fazla farkındaydı. Görüşmede, dörtgenlerin ortak özelliklerini ve benzerliklerini sık sık vurguladı. Dahası, sözü edilen dörtgenlerin özelliklerini ve formal tanımını ezberlemek yerine kendi kelimelerini kullanarak özelliklerini listeledi ve açıklamalarını GeoGebra ile ilgili tecrübelerine dayandırdı. Örneğin, Merve'nin eşkenar dörtgenlerin özelliklerini listelemesi istendi ve o şu cümleleri söyledi: " GeoGebra dosyasında paralelkenarın tüm kenarlarının uzunluğu eşit hale getirdiğimizde eşkenar dörtgen elde ederiz. Ayrıca karşıklı köşelerdeki açıların derecesinin eşit olması gibi paralelkenarın bazı özellikleri de korunmuştur. Ancak paralel kenar ve eşkenar dörtgeni birbirinden ayıran kenarlarının uzunluklarıdır. Öte yandan paralelkenar tüm kenarları eşit uzunlukta olduğunda eşkenar dörtgen gibidir. Aynı zamanda tüm kenarlarının eşit olması durumdan dolayı kare gibidir de. O zaman eşkenar dörtgenin hem paralelkenarın hem de karenin özel bir form olduğunu söyleyebilir miyiz? Hımm. Heyecanlandım. Her dörtgen birbirleriyle alakalı "diye belirtti. Merve'nin açıklamasından anlaşılacağı üzere, GeoGebra'nın yardımı ile paralelkenar ile eşkenar dörtgen ve kare ile eşkenar dörtgen arasındaki ilişkileri daha net bir şekilde fark etti.

Bu çalışmanın sonuçlarına göre, öğretmenlere ve öğretmen adaylarına teknoloji kullanımının öneminin farkında olmaları tavsiye edilebilir. Aynı zamanda teknolojik gelişmelere açık olmalılar ve gelişmleri yakından takip edip sınıflarında kullanmalıdırlar. Aynı zamanda müfredatı geliştirenler de yeni eğitim programlarına teknoloji kullanım ile ilgili maddeler eklemelidirler. Teknolojinin derse entegrasyonu ile ilgili ders planları hazırlanmalıdır. Öğretmenlerin teknolojik donanımlarını geliştirmelidir. Okullara daha fazla teknolojik materyal sağlanmalıdır.

Ayırca matematik eğitiminde dinamik geometri yazılımı ve somut materyal kullanımına yönelik çalışanların sayısı artırılabilir. Bu çalışmada konu olarak dörtgenler konusu incilenmiştir, diğer matematik konuları için de çalışmalar düzenlenmelidir. Aynı zamanda çalışma grubu uygun örnekleme yerine random olarak atanabilir.

APPENDIX G

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

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

YAZARIN
Soyadı :
Adı :
Bölümü :
TEZİN ADI (İngilizce) :

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 bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ